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ORIGINAL ARTICLES.

I.—On some Fossil Entomostraca from South America.

By Professor T. Rupert Jones, F.R.S., F.G.S.

(PLATES X and XI.)

PART II.

(*Concluded from the June Number*, p. 265.)

§ VIII. (4) Estheria Chilensis, Philippi.

PLATE X, Figs. 4, 5.

Estheria Chilensis, Philippi, "Tert. u. Quat. Verst. Chiles," etc., 1887, p. 223, pl. L, fig. 11.

Valves subcircular, approaching subquadrate, like some small Lamellibranchs. Umbo at the antero-dorsal corner, and at an angle of 40° to the extreme curvature of the concentric ridgelets. Hinge-line straight, behind the umbo, about half the length of the longest diameter of the valve. The other edges rounded; the anterior nearly semicircular; the ventral obliquely curving up to meet the steeper and narrower posterior curve.

Size.—Length, 6·4 mm.; breadth, 5·6 mm.

In the dark-coloured hard shale collected by David Forbes at Arica, Southern Peru.

This differs from the associated suborbicular *Estheria* in the Arica shale, both by its rounder shape and especially by the terminal position of the umbo. Also by its more symmetrically regular and more delicate lines of growth.

Lebu, on the coast of Chili, is given, with doubt, as the locality of Professor Philippi's *E. Chilensis*, Fig. 5.

This shape is not unusual among young forms; for instance, the young *E. Forbesii*, "Monogr. Foss. *Esth.*," pl. iv, fig. 9; but the marginal contour differs all round, and the Arica specimen has more numerous ridgelets. The adult form of *E. Forbesii* differs still more distinctly.

The figure of *Estheria* associated with *E. elliptica* in the "Monogr. Foss. *Esth.*," pl. iv, fig. 3, already referred to as an analogue of *Cyclestheria*, may be again quoted, as having a form somewhat like our Fig. 4, though more subquadrate and oblique.

Although there is evidently a close alliance, as far as outward form is concerned, between *Estheria Chilensis* and *Cyclestheria*, Fig. 6,

it would be impossible, without more knowledge of the internal structure, to recognize a generic identity.

An approach to this rare form (*Cyclestheria*) among *Estheriæ* is seen on pl. iv, fig. 3, "Monogr. Foss. *Estheriæ*," a right-hand valve of a small form (possibly a variety) of *E. elliptica*, from the Purbeck of Hanover, and already referred to.

Both Forbes's specimens and Philippi's outline are matched to some extent by Krotow's *Estheria subconcentrica*, Fig. 7, from the "Lower Permian" formation of the Urals;[1] but this apparent alliance is not sufficient to give a geological horizon to the Arica shales. The doubt, moreover, of the locality and geological horizon whence *E. Chilensis* really came, further obscures the possible relationship of these *Estheriæ*.

§ IX. Szajnocha, 1888.

In the "Verhandl. k. k. Geol. Reichsanstalt Wien," 1888, pp. 146, 147, Dr. L. Szajnocha refers to specimens collected by Dr. Rudolf Zuber in South Argentina and Patagonia, especially plant-remains, such as characterize Triassic or Rhætic strata in Australia, South Africa, Germany, Portugal, and Scania. He notices that at Cacheuta shales with plant-remains and phyllopoda occur, and that the latter were described by Geinitz as *Estheria Mangaliensis*, Jones, in his Memoir (1876) on these and other Rhætic plants and animals.

§ X. Summary of the Foregoing Notes.

These result in the determination of four species of *Estheria* found fossil in Peru and Chili, namely—

1. *Estheria Mangaliensis*, Jones, Mangali in Central India, and Mendoza in South America.
2. *E. Forbesii*, Jones, Mendoza, South America.
3. *E. Aricensis*, sp. nov., Arica, South Peru.
4. *E. Chilensis*, Philippi, Lebu (?), Chili; Arica, South Peru.

§ XI. Estheria Mawsoni, sp. nov., and var.

There is also another South-American *Estheria* preserved in the British Museum (Nat. Hist.), and forming part of Mr. J. Mawson's Collection from Brazil, namely (5) *Estheria Mawsoni*, sp. nov., and (5*) variety.

(5) Estheria Mawsoni, sp. nov.

PLATE XI, Figs. 3*a-g*.

Carapace obliquely subovate, moderately gibbose. Umbones at the anterior third of the valve. Hinge-line straight from the umbo to the posterior end, and equal to about two-thirds of the length of the valve. Hinder moiety of the carapace smaller than the front part, the posterior curve being more contracted than the antero-ventral curve. Hence the carapace has a triangular subovate side-view.

Concentric ridgelets or lines of growth, numerous: more than thirty, although those on the umbonal area are obsolete or obliterate. These ridges on the upper part, just below the umbones, are strong,

[1] Mém. Com. Géol. (St. Petersburg), vol. vi, 1888, pp. 469 and 556, pl. ii, fig. 26. See also Brit. Assoc. Report for 1889, p. 66.

with rounded and smooth edges, Fig. 3*d*; thinner and smaller lower down on the valve.

The interstitial spaces are broad on the upper or dorsal moiety of the valves, more and more closely set below, as in other adult *Estheriæ*. The ornament in the broad interspaces consists of small vertical bars, or barrolets, slightly sinuous (Figs. 3*d*, *e*), and occasionally branching and anastomosing to some extent. Towards the free margin, in the narrower intervals, the barrolets become shortened, and merge into a wavy and crenulate pattern (Figs. 3*f*, *g*).

Two carapaces, "L. 304." 1. Long, 7·0 mm.; high, 4·0 mm.; thick, 2·6 mm. 2. Long, 5·7 mm.; high, 3·6 mm.; thick, 3·0 mm. Ovate-oblong, anteriorly short. From shale in a cutting on the Bahia and San Francisco Railroad, 12–13 kilometres from Bahia, on the seaside, between Periperí and Olaria; together with some small Molluscs —*Anodonta Hartii*, White, *A. Mawsoni*, White, *A.*, sp., and *Arca*, sp. There are also other specimens, more or less flattened and decomposed, in sandy shales and clay from cuttings at Pitanga, Pojuca, and elsewhere.

With regard to the ornamentation of this species, two recent forms, *Estheria donaciformis*, Baird,[1] and *E. similis*, Baird,[2] have a bar-ornament in the interstices, of much the same character as that in Figs. 3*d*–*g*, though not so regularly parallel. The valves, however, do not correspond with ours in shape.

Among fossil forms *E. elliptica*, Dunker, and *E. subquadrata*, Sowerby, are characterized by the ornament of vertical bars between the concentric ridges, much like those of *E. Mawsoni*. The shape, however, of the valves in these Purbeckian forms[3] differs from that of the Brazilian species under notice. There is evidence of a similar ornament in some fragments of *Estheria* from the Triassic or Rhætic coal-shales of Dan River, North Carolina.[4] An analogous pattern is present on the shells of some bivalved Mollusca, as *Corbis*, etc.

(5*) Estheria Mawsoni, sp. nov., variety or female form.

PLATE XI, Figs. 4–6.

Ovate-oblong, umbo near the anterior end, in the front fourth of the dorsal edge; postero-dorsal angle more or less distinct; hinge-line straight between these two points, and equal to more than half the length of the valve. The front and hind margins have a steep curve, and are more equal than in *E. Mawsoni*, Fig. 3*a*. But the posterior moiety of the carapace is rather smaller than the anterior; its edge having a somewhat smaller curve than the broad, almost semicircular, curvature of the front end.

This form differs from *E. Mawsoni* (described above) in being nearly oblong in side-view; the front edge curving steeply below the umbo; and the posterior not being contracted. The difference

[1] Proc. Zool. Soc., Annulosa, 1849, p. 89, pl. xi, fig. 5.

[2] Ibid., 1849, p. 90, pl. xi, fig. 7; and 1860, p. 188.

[3] "Monogr. Foss. *Esth.*," 1862, p. 103, etc., pl. iii, figs. 18–29; and Geological Magazine, 1890, p. 389, Pl. XII, Figs. 1, 2.

[4] "Monogr. Foss. *Esth.*," 1862, p. 189, etc., pl. ii, fig. 37; and Geological Magazine, 1890, p. 387.

of shape may possibly be due to sexual condition, since the ornamentation is quite the same on the two forms.

Approximately similar valves are found in the varieties of *E. minuta* and its allies. This form is somewhat like the carapace of the female *E. Packardi*, as figured by Sars.

Flattened casts of the valves occur in brownish shales and in pink clay in the Pitanga and Pojuca cuttings. A carapace from the cutting between Periperí and Olaria measures: Long 5·0 mm., high 3·5 mm., thick 2·5 mm.

Estheria Mawsoni or its variety occurs

At 12–13 kilometres. The cutting between Periperí and Olaria.

At 73–74 kilometres. The Pitanga cutting, between Matta and Pitanga Stations.

At 82 kilometres. At Pojuca Station.

At 84·5 kilometres. At San Thiago (Säo Jago), about six kilometres from the Pojuca Station.

Fig. 5 shows an internal cast with delicate radiating marks, due to the decomposition of the test and its outer layer.

There seems to be a still more truly oblong *variety* of this species, Fig. 7.

§ XII. Ostracoda.

A number of small valves occur in the same soft brownish shale in a cutting at 83 kiloms. between the Station of Pojuca and San Thiago, on the railroad from Bahia, that yields *Estheria Mawsoni*, *Estheriina expansa*, and *E. astartoides*. They lie crowded on some of the bed-planes, and are much obscured by the matrix and imbedment.

In Plate XI the most recognizable forms are depicted (Figs. 8–14); but it is difficult to define their characteristics. Figs. 8 and 9 may belong to an oblong form of *Cythere*; so also Fig. 14, but this is small and nearly oval. Figs. 10 and 11 may be subtrigonal *Cytheræ* or *Cytherideæ*, with the anterior hinge sufficiently strong to influence the outline of the valve. So also Fig. 13, but this valve has on its surface local depressions, which may possibly be indicative of the undulated or constricted valve of a *Metacypris*: see Geol. Mag. 1886, pp. 145–8, Pl. IV, Figs. 1–3; and ibid., 1893, pp. 385–91, Pl. XV, Figs. 1–3. Fig. 12 may be a *Candona* or a *Cypris*.

The general aspect of the Ostracoda is that of a group of probably brackish-water forms, agreeing therein with the associated Estherian phyllopods. Compare the analogous Brazilian specimens treated of in the Quart. Journ. Geol. Soc., vol. xvi (1860), pp. 266–7, pl. xvi, figs. 13–17.

§ XIII. Conclusion.

It is difficult to determine if the groups of fossil Entomostraca above described, represent the brackish-water conditions that obtained in the late Triassic (Rhætic) or the Jurassic and early Cretaceous (Wealden) times. The plant-remains of Mendoza appear to be of Rhætic age. The railway-cuttings in Brazil have not yielded any definite plant-remains; and their fossil shells have

been referred to the Cretaceous system. *Estheriïna* is certainly characteristic of the Brazilian shales in Hartt's "Bahian" series; some of its analogues are far back in the Carboniferous system. *Estheria Forbesii* and *E. Mangaliensis* are such as lived in a late Secondary age;[1] *E. Mawsoni* has the ornament characteristic of some species of early Secondary, or rather earlier date.

EXPLANATION OF PLATE X.

Fig. 1.—*Estheria Aricensis*, sp. nov. Left valve, magn. 3 diam.
Fig. 2.—The same. Left valve, magn. 3 diam.
Fig. 3.—The same. A large specimen, drawn from a hollow mould of a left valve, magn. 3 diam.
Fig. 4.—*Estheria Chilensis*, Philippi. Right valve, magn. 3 diam.

Figs. 1–4, from Arica, Peru, collected by David Forbes, are in the British Museum.

Fig. 5.—*E. Chilensis*, after Philippi. Nat. size.
Fig. 6.—*Cyclestheria Hislopi*, after Sars. Magn. 3 diam.
Fig. 7.—*Estheria subconcentrica*, after Krotow. Nat. size.

EXPLANATION OF PLATE XI.

Fig. 1.—*Estheria Forbesii*, Jones. *a*, left valve, magn. 3 diam.; *b*, part of the superficial ornament, magn. 75 diam. From Cacheuta, Argentine; collected by D. Forbes, and in the British Museum.
Fig. 2.—A group of the same species, after Philippi. Nat. size.
Fig. 3.—*Estheria Mawsoni*, sp. nov. *a*, carapace, showing the left valve; *b*, end view; *c*, edge view. *a*, *b*, *c*, magn. 6 diam. *d*, *e*, *f*, *g*, parts of surface, magn. 75 diam.
Fig. 4.—The same, variety or ♀. *a*, left valve imperfect, magn. 6 diam.; *b*, part of surface, magn. 75 diam.
Fig. 5.—The same, variety or ♀. An internal cast of a left valve, showing radiating lines caused by the decomposition of the test and its minute interstitial barrolets; magn. 6 diam.
Fig. 6.—The same, variety or ♀. *a*, carapace showing left valve; *b*, edge view; *c*, end view: all magn. 6 diam.
Fig. 7.—The left valve of a variety of *E. Mawsoni*. Shorter and squarer than the other examples, magn. 6 diam.

Figs. 3–7 from the Bahia and San Francisco Railroad, at 12–13, 73–74, 82, and 84·5 kilom. from Bahia.

Figs. 8–14.—Small Ostracoda (possibly *Cythere*, *Cytheridea*, *Cypris*, *Candona*, and *Metacypris*); magn. 40 diam.

II.—On a New Specimen of the Stegocephalan *Ceraterpeton Galvani*, Huxley, from the Coal-measures of Castlecomer, Kilkenny, Ireland.

By Arthur Smith Woodward, F.L.S., F.G.S.

(PLATE XII.)

SINCE the original description of *Ceraterpeton* by Huxley thirty years ago,[2] several specimens have been referred[3] to this interesting Stegocephalan genus, one even to the typical species,

[1] See "Monogr. Foss. *Esth.*," Pal. Soc. 1862, Table, p. 114.

[2] Huxley and Wright, "On a Collection of Fossil Vertebrata from the Jarrow Colliery, County of Kilkenny, Ireland": Trans. Roy. Irish Acad., vol. xxiv (1867), p. 354, pl. xix.

[3] E. D. Cope, "Synopsis of the Extinct Batrachia from the Coal-measures [of Ohio]," Rep. Geol. Surv. Ohio, Palæont., vol. ii, pt. 2 (1875), p. 372, pl. xli, fig. 4; pl. xlii, fig. 2. A. Fritsch, "Fauna der Gaskohle," vol. i (1880), pp. 136–46, pls. xxvii–xxx.

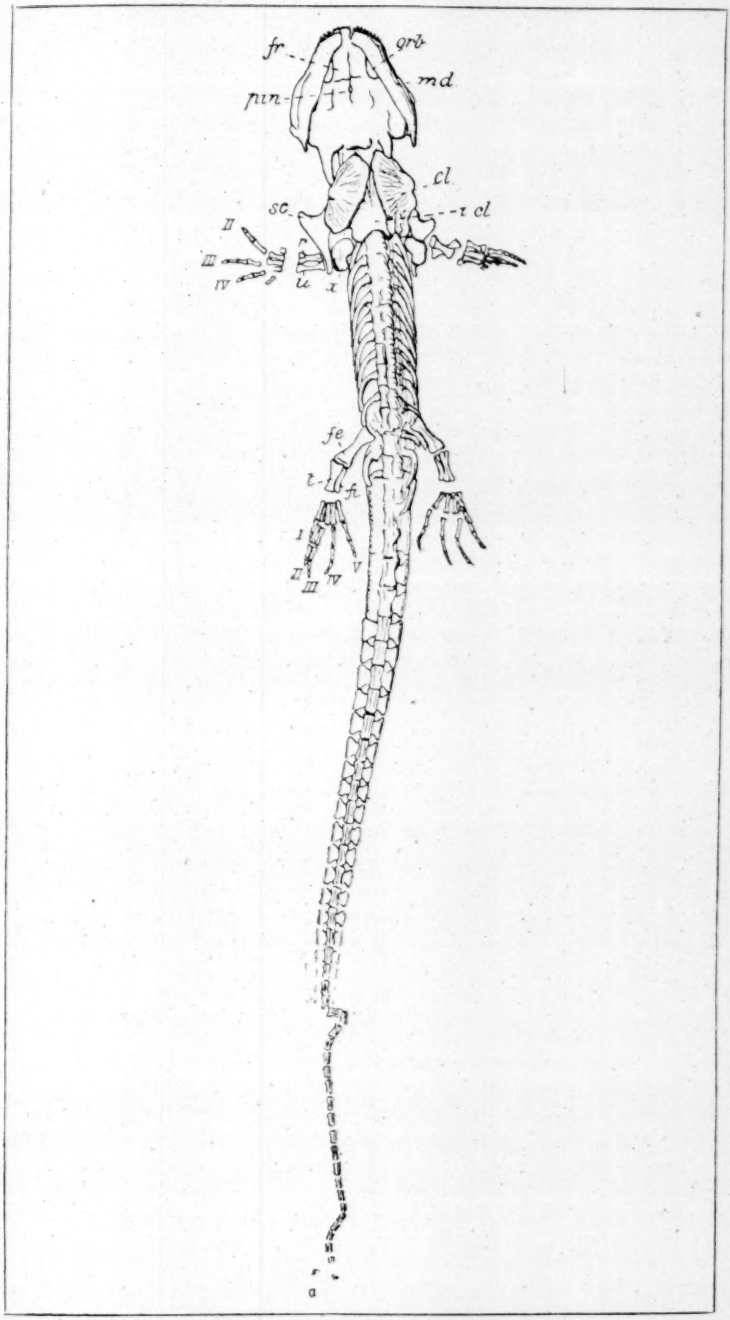
C. Galvani.[1] No new examples from the typical locality, however, have hitherto been described, and our knowledge of the Irish form has thus remained without extension. Now, a nearly complete new skeleton has been discovered at Castlecomer, by J. G. Robertson, Esq., of Dublin, and I am indebted to him and to Professor Grenville Cole for the opportunity of studying it, and adding somewhat to the known characters of the animal.

Like the previous specimens, the new fossil seems to consist of little more than bituminous matter replacing the substance of the bony skeleton; but it stands in relief from the surface of the shale, and clearly exhibits the contours indicated in the accompanying outline sketch (Plate XII), which is of the natural size. The skeleton is exposed from beneath and wants only the absolute extremity of the tail.

The lateral borders of the head are covered by the slender mandibular rami (*md.*), which are a little crushed apart at the symphysis and allow the premaxillæ to be observed. Remains of a regular close series of small blunt teeth are conspicuous in front; while two teeth which seem to belong to the right mandibular ramus are somewhat larger than the others and a little tumid. The anterior part of the palate is destroyed, thus completely exposing the cranial roof from within. Part of the border of the orbits (*orb.*), in their characteristic forward situation, is clearly shown. The pineal foramen (*pin.*) is also well displayed. There is a distinct median suture between the frontal (*fr.*) and parietal bones; but the transverse suture between these elements is a little uncertain, though it seems to have been as indicated in the figure. As in the previous specimens, the posterior cornua of the skull seem to have been firmly fixed to the other elements. That of the right side is almost completely exposed, and its length is about equal to half that from the occiput to the end of the snout; its surface is quite smooth.

Immediately behind the head the axial skeleton is obscured by the crushed remains of the pectoral arch, which probably covers five or six vertebræ; but between this and the hind-limbs ten vertebræ are distinctly shown in regular series, each bearing a pair of very stout curved ribs. The vertebræ themselves are exposed in side view, showing the slender constricted centrum and the crushed remains of the expanded neural arch. The ribs are nearly uniform in size. The pelvic region is obscure, but it does not seem possible to count more than one vertebra as sacral. Then follow two caudal vertebræ with a stout backwardly directed rib firmly fixed to each transverse process. The remaining caudals must have been almost or completely destitute of these processes. About 25 of them are preserved in regular undisturbed series, turned upon their side, and displaying the characteristic fan-shaped neural and hæmal arches. These arches

[1] J. Ward, "The Geological Features of the North Staffordshire Coal-Fields": Trans. N. Staff. Inst. Mining Engin., vol. x (1890), p. 187, pl. ix, fig. 2. C. W. Andrews, "Note on a Specimen of *Keraterpetum Galvani*, Huxley, from Staffordshire": Geol. Mag., Dec. IV, Vol. II (1895), pp. 81–4, Woodcut.



Ceraterpeton Galvani, Huxley (nat. size).
Coal-measures : Kilkenny, Ireland.

form symmetrical pairs, gradually becoming atrophied towards the hinder members of the series, and their distal margin is in some cases distinctly crimped. At the twenty-seventh caudal vertebra, where nothing but the delicate elongated centra can be seen, the tail is a little distorted and the remainder is only imperfectly preserved; but there cannot have been less than 25 centra in this attenuated terminal portion. The caudal region is thus about three times as long as the abdominal region.

As already mentioned, the crushed remains of the pectoral arch are conspicuous immediately behind the head. The clavicles (*cl.*) are elongate-ovate in shape, and marked with a linear ornament which radiates from a boss on the outer lateral border of each. They distinctly meet in the middle line in front of the interclavicle (*i.cl.*), which tapers forwards, and seems to be fractured by crushing upon the vertebral column at its hinder border. The latter bone also shows feeble traces of a radiating ornament, but does not bear any longitudinal ridge. On either side of the clavicular apparatus, but partly obscured on the left, the internal element (*sc.*), provisionally termed scapula by Huxley, is well preserved, with the excavated triangular end forwards and the tapering pointed extremity directed backwards. The small, almost reniform bone (*x.*) touching the latter on the right, overlapping it on the left, may be either a coracoid or the crushed remains of the humerus. The radius (*r.*) and ulna (*u.*) are well displayed on both sides, those on the right in juxtaposition, those on the left crossing each other. The ulna is slightly the larger of the two bones, and there is some appearance of a small olecranon process. The carpus is represented by a blank space, and must thus have remained unossified. The digits are imperfectly preserved, a little crowded on the left, spread out on the right, and it is doubtful whether there are more than four. The metacarpals and all the phalanges except the unguals are a little expanded at each end, while the terminal elements just mentioned are relatively small, slender, and pointed. The first digit preserved on the right side is probably No. II, and exhibits three phalanges; the next digit, also complete on the left side, has four phalanges; No. IV on the right side has again only three phalanges; No. V is not satisfactorily displayed.

The fragmentary remains of the pelvis are too obscure for description, but the hind-limbs are well preserved. They are slightly larger than the fore-limbs and clearly exhibit five digits, each terminating in a relatively small and pointed ungual phalange. The femur (*fe.*) is robust and slightly expanded at each end, much longer than the tibia and fibula, indeed as long as the crus with the tarsus indicated by the vacant space. The tibia (*t.*) is also stouter than the fibula (*fi.*), and its proximal end is much more expanded than its distal end. There is no trace of ossification in the tarsus, but the five metatarsals and their appended digits are so well ossified that the bones may almost be described as terminated with complete condyles. The first digit (I) is relatively small and is crushed upon the second in both feet, but on the right side it

exhibits two phalanges; Nos. II to V, of the proportions shown in the figure, are beautifully displayed on both sides, and their phalangeal formula is clearly proved to be 3, 4, 4, 3.

No impressions of the skin are preserved, and there is no trace of the scutes of the ventral dermal armour.

Mr. Robertson's new specimen of *Ceraterpeton* is thus of special importance as making known for the first time in the type-species the characters of the clavicular apparatus, the phalangeal formula of the hind-limb, and the relative proportions of the tail; for the fossil was obtained from the same formation and locality as the original specimens, and the only important differences it presents may easily be explained as the result of accident. On comparison it will be observed to differ a little in the shape of the head, which is relatively narrower; it also seems to differ in having two or three fewer presacral vertebræ. As Huxley remarks, however, the head in the two examples he figures is not improbably widened by crushing; while there may be a mistake in estimating the number of vertebræ covered by the clavicular plates in the fossil described above.

It now appears, indeed, that the amended diagnosis of *Ceraterpeton* based by Fritsch on specimens from the Lower Permian of Bohemia, does not apply to the genus with which Huxley was dealing when he originally proposed the name. It has already been pointed out by Andrews[1] that the skull of *Ceraterpeton* discovered by Ward in the Coal-measures of North Staffordshire, differs in most essential particulars from the Bohemian skulls ascribed to the same genus by Fritsch. It is now clear that there are equally important differences in the trunk and limbs. The species from Bohemia exhibits (i) more numerous presacral vertebræ and more slender ribs, (ii) a clavicular apparatus of entirely different shape, as interpreted by Fritsch, and (iii) distinct ossifications both in the carpus and tarsus. The generic name *Scincosaurus* originally applied by Fritsch[2] to the Bohemian specimens ought thus to be adopted for the species generally quoted under the name of *Ceraterpeton crassum*; while the only definitely known species of *Ceraterpeton* is the type. The skull from the Coal-measures of Ohio described by Cope under the name of *C. lennicorne* seems to be correctly placed here; but of this animal the trunk still remains unknown.

EXPLANATION OF PLATE XII.

Ceraterpeton Galvani, Huxley; outline of nearly complete skeleton, ventral aspect, nat. size. Coal-measures: Castlecomer, Kilkenny, Ireland. *cl.*, clavicle; *fe.*, femur; *fi.*, fibula; *fr.* frontal; *i.cl.*, interclavicle; *md.*, mandible; *orb.*, orbit; *pin.*, pineal foramen; *r.*, radius; *sc.*, supposed scapula; *t.*, tibia; *u.*, ulna; *x.*, coracoid or humerus. [Collection of J. G. Robertson, Esq., Dublin.]

[1] Loc. cit. 1895, p. 83.
[2] Sitzungsb. k. böhm. Gesell. Wiss. 1875 (1876), p. 72.

III.—More Notes on the Terraced Hill Slopes of North Oxfordshire.

By Edwin A. Walford, F.G.S.

THE green slopes of many of the minor vales of North Oxfordshire are scored with parallel terraces or terraced banks frequently of such regularity in depth of step and slope as to present to the mind any other origin for their formation than that of the every-day work of natural forces. A student who has mastered the elements of this natural work and has gained a clue to the mode of the making of the terraces reads with some amusement the varied accounts of their human origin. The best summary of these accounts is given in Mr. G. L. Gomme's book "The Village Community."[1] And though these accounts refer to wider tracts of country than can be discussed here, our local antiquarians assign similar human causes, and we read of the terraced slopes as camps, entrenchments, vineyards, bear-gardens, and the like.

It continues to be so in the face of the fact that—

(1) The so-called vineyards present every face to the sun, and as frequently face N.E. as S.W.

(2) That the entrenchments would protect nothing, and occur in places impracticable for defensive work.

(3) And that as camps, the question of water supply is generally a fatal one to such use.

Now Mr. Gomme's catalogue runs thus:—

Elf furrows (human origin?).

Places for militia to arrange themselves on—for the chieftain's review.

Roman works—itinerary encampments.

Terraces of cultivation.

Places for people to witness Druidical ceremonies.

The geological theories of Mr. Poulett Scrope, Dr. Mackintosh, and Dr. Darwin, I quoted in my paper printed in 1890.

I first briefly drew attention to the terraced fields in my account of "Edge Hill," published in 1886. Four years later, in the Journal of the Northamptonshire Natural History Society, I dealt with the subject at some length. Since then other localities and new conditions have come under my notice, and with them I propose to deal.

To cite again the causes of terrace formation: First and foremost is the downward *creep* of the surface and subsurface soil. But we are met by the objection that the soil creeps downwards from every hilltop, and that all high land is in a state of movement towards vale and sea: yet terraces do not occur upon every hillside.

Our home valleys give the clue. Almost all the terraces occur upon one precise geologic line. That line is a series of marls and clays, with variable proportions of sand, which come in below the red rock bed (the higher part of the zone of *Ammonites*

[1] G. L. Gomme, "The Village Community," pp. 82–8. (Walter Scott, London, 1890.)

spinatus). The marls are porous, they are non-cohesive. The lime in them has either been removed, leaving them in a loose, incompacted state, or it is in process of removal by the constant saturation and passage of water. Oft-times we forget that the heated land-surface of summer-time must draw again from below that which it allowed to pass through.

Although it is common enough to see on hill slopes small terrace-like ridges caused by the downslide of surface soil, yet it is not until we reach the position of the marls of the Middle Lias that the downslide is made prominent, and that terraces, from an incipient stage like the ordinary grass ridge to minor and major terraced banks of varying regularity of form, can be traced. On these slippery slopes the soil must creep. The rain and rainwash loosens the light soil and marl below and about the roots of the herbage, and urges its movement downward. So, just as the children make ground-slides down the steep smooth banks, so the Earth-Mother makes these pleasant folds along the sides of her green vales as she strips away her waste for the use of the lower lands.

Below these slippery marls are depths of compact blue clay (the zone of *Ammonites margaritatus* if near the marls). A little below the point where the marls and clays meet is the line of water outflow—its course can easily be traced around every hill slope. Along this line there is constant removal of the marls by chemical and mechanical solution. The effect is the loosening and sliding of the beds downwards and outwards. The jumbled state of the land along the line is often evident; at Edge Hill it is very prominent. If there be "hummocky" ground it is thereabouts. The pressure of the overlying mass of rock (there twenty-five feet thick) with the associated marls has no doubt aided in the squeezing out of the soft beds along the water-line. Hence pressure appears as a factor in the making of terraces. The terraced slopes of the chalk hills and the lynchets of the sandy oolitic hill-caps of Dorsetshire frequently begin near the crest. The water-line of the former is probably the Gault, and of the latter the line is at the top of the clays of the Upper Lias.

Furthermore, it appears that the free passage of water *through* the rock and marl is necessary, for the Upper Lias Clays have on the Oxfordshire terraced hills either been wholly stripped from the hill-tops or have been pushed far back by atmospheric denudation. Regularly terraced slopes are not found under clay-caps; the clay cover may roof the hilltop, but the appearance of terraces is coincident with its wearing away from the top of the bank.

I have noted that the flats of the terraces, especially of the lower ones, are often water-soddened, but whether the flats have relationship to minor lines of outflow is not clear and is scarcely probable.

The amphitheatre form of terraced land is always a valley head. The outflow of the stream—the valley-maker—marks ordinarily the base of the amphitheatre. More frequently the terraces of the valley head are small in step, their curvature is broken, and the depth of

step irregular. Such an instance is Kenhill, near Shennington; an instance of greater regularity of curvature and greater depth of step is the Bear-garden, Banbury. It has been described as a Roman amphitheatre, and its name Bear-garden indicates a probable former use.

The best instances I can cite are the terraced banks of Rattlecombe Slade and the adjoining ground near Shennington, which I described in my previous paper. The Shennington valley, as well as the Horley and Hornton vale, begins near the Edge Hill escarpment and flows from its ridge onwards in a south-westerly direction towards the Cherwell vale. Around the high lands above Hornton, where the Hornton vale begins, are some terraces, and also its slopes are terraced in its course towards Horley. Miniature terraces made by the down-drift of soil may be seen on the west side of the brook below the hedgerow of the ploughed field and high up the bank. The names Fermere[1] Lake and Angermere Hill suggest the former spread of water over the vale, and in the black peaty soil of Angermere Hill-side the remains of large deer have been found. Another fork of this vale runs alongside Adsum (or Hadsham) plantation, and in part is known as Adsum Hollow. The terraces sweep in regular curves alongside the high banks of the stream, and where it joins the main vale to the north of Horley the steps are of so prominent a type as to give the name of Steps Meadow to the ground. The highest terrace gives the greatest depth of step, but the contour of the top terrace is usually less regular than that of the two or three lower ones. The beautiful terraced slopes which cover the three sides of Gredenton Camp on the Burton Dassett Hill, I have previously described.

The steep slopes of the terraces are often covered with gorse, whilst the flat tops are usually clear. Although some allowance must be made for the work of the husbandman in clearing the land, the loose drier soil of the bank slope seems to favour better the growth of the gorse.

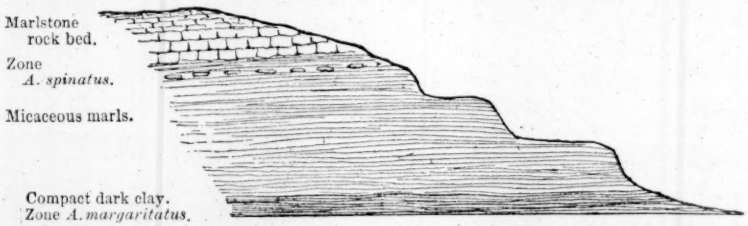
It is not possible here to attempt any description of the terraced slopes of the chalk hills, nor of the lynchets of Dorsetshire. Reasons like those I have brought forward will no doubt prove their similar method of formation. The sandy marls of the Dorsetshire Inferior Oolite have, in fact, a composition approaching that of the marls of the Middle Lias of the Midlands. The *lynches* of Oxfordshire, high and overhanging banks of streams, occur generally along the line of the micaceous marls.

The sand of an hourglass will, in its running, make miniature ridges, but in the few other simple experiments I have tried I have not been successful in making them artificially.

The section of a terraced hill in the accompanying figure may help us to understand better how the continuous work of the every-day

[1] In an old ward map belonging to James Stockton, Esq., of Banbury, I have noticed the words 'mere' or 'mare' affixed to the names of lands. It would seem as if it better applied to water spread over ill-drained land rather than in the other sense indicating a boundary.

natural forces moulds and shapes hill and vale to make the soft scenery of the Midlands.



Hill Section to show the Formation of the Terraced Slopes.

Faults.—Where there are terraced banks I have been able to trace in nearly every instance also the presence of a contiguous fault. At Gredenton Hall, near Fenny Compton, Warwickshire, a small exposure shows the fault at the south-west end where the marlstone rock has slipped down to the level of the marls, and, as it were, squeezed the banks out of the flanks of the hill. The faults are probably part of the step-faulting common to every hillside. Here and there the slope of the line of terrace is in the opposite direction to the dip of the vale.

The cols and coombs of our minor vales are full of varying examples. The main vale (the Cherwell) is of low grade and is void of examples. The banks of the minor vales (where there is uniformity of stratigraphical conditions, as over the area covered by the banks) have a grade varying in steepness in proportion to approach to the source. It is to the region bounded by the Edge Hill escarpment and the Burton Dassett Hills that these notes more particularly apply.

The steps of the meadow bank, the steps of the mountain from summit to plain, parallel roads, cirques, corries, and the like, have a common origin downslide, the movement of rock along lines of drainage towards the lines of slower disintegration. Whether we study meadow banks or mountains, uniformity of plan shows through the whole.

Note.—See article in the Geological Magazine, 1869, Vol. VI, pp. 537–42, by G. Poulett Scrope, F.R.S.

IV.—Note on a Section of the Pleistocene Rubble Drift near Portslade, Sussex.

By S. Hazzledine Warren.

THE interest of this section lies in its bearing on the theoretical considerations relative to the causes that produced the extensive deposits of Rubble Drift in the South of England.

The old sea cliff, which is now protected from the sea by a shingle-bank some little distance away, was, at the time of my visit, in November, 1896, being cut back for the extraction of flints and sand. The following section was noted, the thicknesses given being only approximate :—

4. Surface soil . . . . . 1 ft.
3. Dark-coloured stony clay descending into pipes . 6 in. to 3 ft. or more.
2. Contorted chalky loam, a large proportion of its mass being composed of flints, often broken, said to yield mammalian remains at the base . . . . . 10 ft. to 12 ft.
1. Light-coloured sand, red in the upper part, with layers of well-rolled flint pebbles, and many concretionary nodules, which are sometimes tabular. Marine Mollusca and Balanidæ fairly abundant: *Mytilus edulis* in the pebbly layers, *Natica*, etc., in the sand . . . . . seen to 9 ft.

No. 1 is the well-known Raised Beach, in which the shells, particularly *M. edulis*, have frequently their colour preserved.

No. 2 is locally known as "Coombe Rock." It is the "Rubble Drift" of Prestwich (1892), and the "Elephant Bed" of Mantell (1822).

No. 3 much resembles the Trail (Fisher, 1866) of the valleys of the Thames, Lea, etc., but could not safely be correlated with that deposit. It has more probably been formed in place by solution of the calcareous matter out of No. 2.

The Rubble Drift here presents rather the appearance of ice having been concerned in its formation; although, as the Raised Beach is undisturbed, this could not have been in strong force. The contortions may very possibly have been produced by the melting of intercalated blocks of ice. I am by no means sure, however, that a moving mass of semi-fluid mud and stones would not assume contortions similar to those presented in this exposure, without the aid of ice, in a manner analogous to the knotty twists and tortuous waving lines so frequently seen in vitreous (and, of course, devitrified) lava-flows.

On Sir Joseph Prestwich's theory (Q.J.G.S., vol. xlviii, p. 271) of this drift having been formed by submarine currents produced by the rising of the land after a short dip in the sea, these contortions are inexplicable. And, in addition, there is no direct evidence of such a submergence; indeed, the absence of marine shells is strong negative evidence against it. Neither is there any particular *a priori* probability of such an event.

That of Mr. Clement Reid (Q.J.G.S., vol. xliii, p. 364) I am inclined to accept as the best explanation yet suggested. There is no indication of glaciation, in the full sense of the term, south of the Thames. But the ground must have been deeply frozen during the winter. The summer thaw and rains would cause extensive floods; for, the chalk being frozen, and therefore impermeable, all the rain and water from the melted snow would sweep over the surface of the ground, and carry along large quantities of chalk rubble and flints. Many of the flints would become broken and battered, but not much water-worn, which is the appearance they actually present in the Rubble Drift.

This section is admirably interpreted by this theory. For whether the contortions were produced by the melting of contained blocks of ice or masses of frozen snow, or whether by the internal movements of a semi-fluid mass of mud and stones, or were referable to both

causes, in part, it would be equally in accordance therewith. They are, in either case, a stumblingblock to that of Sir Joseph Prestwich.

The Palæolithic implements, however, that have been found in the Rubble Drift, present rather a difficulty. For such implements usually appear to be of later date than the Chalky Boulder-clay. And, if this theory be correct, one would suppose that the Rubble Drift should have been formed contemporaneously with that deposit, if not previously. I hardly think it can be the equivalent of the Trail, as held by Mr. J. Allen Brown (Journ. Anthrop. Inst., vol. xxii, p. 66), because, in that case, a strong semi-glacial deposit would be the equivalent of a comparatively weak one situated farther north, which scarcely seems probable.

But this is a question of probabilities, not of facts. Mr. Clement Reid's theory not only gives a satisfactory explanation of the origin of the Rubble Drift, but also refers the formation of the dry chalk valleys to the same cause. This speaks volumes in its favour, for the value of a scientific theory depends upon the range of phenomena that it co-ordinates.

V.—Notes on the Age and Structure of the Gneissose-Granite of the Himalayas with reference to Mr. Middlemiss's Memoir on the Geology of Hazara.

By Lieut.-General C. A. McMahon, V.P.G.S.

I AM indebted to Mr. C. S. Middlemiss, Superintendent of the Geological Survey of India, for a copy of his Memoir on the Geology of Hazara and the Black Mountain recently published.[1] Mr. Middlemiss has embodied in his Memoir the results of an unfinished survey by Mr. A. B. Wynne, late of the Geological Survey of India, and by linking these with his own more recent work, has given us an interesting and valuable Memoir on the Geology of the Himalayan district of Hazara.

As there seems to be no prospect of a systematic survey of the whole Himalayas being undertaken during the lifetime of the present generation, the geological student has to content himself with such information as observers are able to glean during visits of limited duration to these mountains. The Government of India doubtless considers the search for coal, and other economical products, as more pressing than investigations having the elucidation of theoretical problems for their aim; hence the members of the Geological Survey are only able to devote limited periods during occasional visits to the Himalayas to pure geology.

Mr. Middlemiss's Memoir contains a mass of well-digested facts, and he draws many inferences from those facts with which I cordially agree. There are some theoretical questions, however, which have an important bearing on the history of the Himalayas on which we differ; and I propose, for the sake of brevity, to limit myself in this paper to the discussion of these questions.

[1] Memoirs of the Geological Survey of India, vol. xxvii.

The first point is the *age* to be assigned to the intrusion of the gneissose-granite.

Mr. Middlemiss discusses, among other things, the origin of the granite: namely, whether it was an ancient gneiss (p. 273); a metamorphosed sedimentary rock (p. 275); or a true granite. I do not propose to go into these questions, because Mr. Middlemiss freely admits that, whatever its origin and mode of birth may have been, it behaved as a granite when it intruded into the Himalayan strata. If a rock be mineralogically and functionally a granite, I am not disposed to make curious inquiries of Vulcan as to whether it has a bar sinister on its escutcheon. If it behaves like a granite and a gentleman after its introduction into polite geological society, I am satisfied.

It is not alleged that the foliation to be observed in the granite is due to the original taint in its birth; on the contrary, another and post-genital cause is assigned. This discussion as to its origin is therefore, as far as the geology of the Himalayas is concerned, a purely academic one. Mr. Middlemiss holds that the granite—

1. "Must have been so heated as to get at least into a plastic state in which it was capable of considerable movement under pressure along lines of least resistance" (p. 273); and was capable of "in part consuming" the strata into which it was intruded (p. 274).

2. That it functionally acted as an igneous intrusive rock (pp. 274, 276).

3. That it sent off dykes, sills, and intrusive veins into the adjoining rocks — instance, figs. 1, 2, 4, 44, 45, 51, and 52, and pp. 61, 63, and 64.

4. That it is "always surrounded by a concentric zone of well-defined extra metamorphism" (p. 276).

5. That it contains numbers of "included fragments of schists and quartzite" (p. 63).

As the gneissose-granite was intruded into the Himalayan strata long subsequent to their deposition, and as it uniformly behaved as an igneous rock, I think we may content ourselves with calling it a granite and pass on to consider the actual date of its intrusion. Mr. Middlemiss considers that its age "must be at least Pre-Triassic, whilst it is possible that it may be earlier than Carboniferous, e.g. Silurian" (p. 278). The reasons which the author assigns for this opinion, briefly stated, are as follows:—

1. The absence of metamorphism in Tertiary beds (p. 137); and the non-occurrence of granite in Tertiary strata (p. 277, footnote).

2. The occurrence of Murree beds and Nummulitic limestone in direct and normal superposition immediately above thin-bedded rocks exhibiting distinct metamorphism (p. 135).

3. (*a*) The non-occurrence of intrusive granite in the "Tanols."
   (*b*) The opinion of the author that the granite is older than the "Tanols."
   (*c*) The probability that the "Tanols" derived their materials from the granite.

(*a*) (*b*) (*c*) will be found at p. 239 (6).

4. The probability that the "volcanic rocks of Kashmir (the amygdaloids) of about Silurian age are subærial representatives of the granitic cores" (p. 278).

5. The author also relies on the following points :—

(*a*) The Trias limestone in Hazara is unmetamorphosed (p. 277).

(*b*) The Infra-Trias of Hazara is metamorphosed in a minor degree compared with the slate series (p. 277).

(*c*) Much, if not all, of the metamorphism of the Infra-Trias is attributed to the invasion of basic dykes (p. 277).

I propose to take the above five points seriatim.

1. *The absence of metamorphism and the non-occurrence of granite in Tertiary beds.*—I do not see how this fact proves that the granite is of Pre-Tertiary age. It would only prove, at most, that in the sections in which Tertiary beds occur the granite did not rise as high as the Tertiaries. Mr. Middlemiss remarks (p. 274) that the granite, "if conceded a granite origin," "was formed as great laccolites, *deep down below the surface of the earth*" (the italics are mine), "under such enormous pressure of the superincumbent rock that an irruptive function was generally denied it." If so, how could these deep-seated laccolites be expected to appear as eruptive rocks among beds as high up in the geological series as the Tertiaries?

The appearance of the granite, according to the author, is limited to his crystalline and metamorphic zone, which in Hazara was the first to rise, rose the highest, and was denuded the most (pp. 261, 265). The present boundaries of the Sewalik and Nahan Tertiary rocks on the flanks of the Himalayas are also the limits of their original deposition.[1] Mr. Medlicott found that "the Himalayan mountain area was defined before the deposition of the Sabathu nummulitic rocks,"[2] and I do not gather from Mr. Middlemiss's Memoir that he challenges this position for the rest of the Himalayas. Indeed, he tells us (Memoirs G.S.I., xxiv, 122): "I think we are justified in denying that they [the Eocene nummulitic rocks] ever existed over those higher tracts of the outer and central Himalaya where never an outlier of them has been detected." If Tertiary rocks were never deposited over the zone invaded by the granite, how does its non-appearance in Tertiary strata, and the absence of contact-metamorphism in Tertiary beds, throw light on the age of the granite? Manifestly the points relied on do not prove the author's contention.

The second piece of evidence is the fact that Murree (Lower Sewalik) beds and Nummulitic limestones rest in direct and normal superposition immediately above thin-bedded rocks exhibiting distinct metamorphism (p. 135).

The author relies on the evidence afforded by the Laichi Khun section (see footnote to p. 277) to refute my theory that the granite

[1] Manual G.I., 2nd edition, p. 468. Memoirs G.S.I., Middlemiss, xxiv, pp. 120–2; xxvi, pp. 266–8.

[2] Memoirs G.S.I., iii, p. 174.

is of Tertiary age. "After what has been said," he writes, "concerning the Laichi Khun section, its Tertiary age is plainly impossible." In view of this contention it becomes necessary to examine the Laichi Khun facts in some little detail.

The description of the Laichi Khun and Hubeeboollah section begins at p. 129 in the Memoir under consideration, and the argument based on the facts is stated at p. 135 as follows:—"I must now invite attention to one of the most important deductions that may be drawn from the Gurhee-Hubeeboollah sections. In a previous memoir (Physical Geology of the Sub-Himalaya of Kumaun and Garwall [1]) I remarked on the absence of metamorphism in the Upper Tertiaries and Nummulitics in the vicinity of the schistose and granite area of Kalogarhi (also called Kalandanda, and latterly Lansdowne) as offering a not very rigid proof that the Tertiaries at least were deposited later than the date of the general metamorphism of the Himalaya by the intrusion of the gneissose-granite."

I objected to this evidence in a footnote to my Presidential Address,[2] on the ground that the granite appeared to be five miles distant from the Tertiaries; and Mr. Middlemiss seems to have felt the force of it, for he now says that the "proof" is not "very rigid," and proceeds as follows:—

"We have here before us in this corner of the mountains a much more satisfactory proof, inasmuch as the Murree beds, the Nummulitic limestone, together with the sandstone beds at the base, lie all in direct and normal superposition immediately above thin-bedded rocks exhibiting distinct metamorphism. They form outliers capping the tops of the hills, whilst the schistose slates form the base of the same hill range."

The author does not tell us what series the "thin-bedded rocks exhibiting distinct metamorphism" belong to; but I presume, from his description of the section between Srikote and Laichi Khun (the section referred to, pp. 131, 132), and from the geological map which accompanies the Memoir, that these beds belong to the Infra-Trias. Notwithstanding the use of the phrase "normal superposition," the beds can hardly be referred to the Cretaceous, Jurassic, or Triassic series, as that would be opposed to the author's argument that the contact-metamorphism of the granite goes no higher, at most, than the Infra-Trias. Neither the map nor the detailed description of this section show the presence of beds of the "Tanol" or of the "Slate" series between Hubeeboollah and Laichi Khun; and as it would not get rid of the difficulty, but, on the contrary, increase it, to refer the thin-bedded rocks to either of these series, I am forced to the conclusion that the metamorphosed beds belong to the author's Infra-Trias series. But, even so, it is clear that a tremendous fault, or a great unconformity, intervenes between the Nummulitic and Infra-Triassic beds. The author writes at p. 131: "In this section, which shows no signs of faulting above the Infra-Trias, there is neither Trias, Jura, nor Cretaceous represented.

[1] Memoirs G.S.I., xxiv, pt. 2.
[2] Proc. Geol. Assoc., vol. xiv, p. 93.

. . . . The absence of these formations, coupled with the con glomeratic character of the base of the sandstones, and the inclusio among it of an angular clastic breccia so plainly remade from th *in situ* brecciated cherty bands of the Infra-Trias, argue an uncon formity at this spot." Just so; but what then becomes of th author's argument at pages 135 and 277 (footnote), that the presenc of unaltered Tertiary rocks resting in "direct and normal super position immediately above thin-bedded rocks exhibiting distinc metamorphism" shows that the Tertiaries were deposited later tha the metamorphism of the strata, and makes the Tertiary age of th granite "plainly impossible"?

If a vast lapse in geological time exists between the metamor phosed Infra-Trias and the unmetamorphosed Tertiaries; and i great thicknesses of beds belonging to the Triassic, the Jurassic, an Cretaceous periods (or some of them) have been removed by erosion how are we to say what agent caused the metamorphism of the Infra Triassic strata on which the Tertiary beds now rest?

We have positively no ground for assuming that the metamor phosing agent in the case of the Laichi Khun beds was granite Granite does not apparently occur in any part of this section and the author tells us at page 277 that the metamorphism exhibited by the Infra-Trias "may be attributed to the eruption o basic dykes." The metamorphism of the schistose beds under dis cussion may have been due to regional metamorphism, to dynami causes, or to the intrusion of basic igneous rocks, for all we know What, then, does this section prove regarding the age of the granite?

If, for the sake of argument, we were to assume, without a tittl of evidence to support the assumption, that the metamorphism of the thin-bedded rocks was due to the contact action of granite, wha would it prove as to the age of the granite? The fact, it seems t me, would only prove that the granite did not, in this particula section, rise as high as the Tertiary beds; it would not prove that it was Pre-Tertiary in age. The author tells us (p. 274) that the granite "was formed as great laccolites, deep down below the surface of the earth, under such enormous pressure of the superincumbent rocks that an eruptive function was denied it." That being so, the section relied on, even on the assumption that the metamorphism was caused by granite, would prove no more than that the granite was kept down by the "enormous pressure" of the cover, and did not rise as high as the Tertiary beds. It would not prove that the granite was intruded into the strata where it is now found before the Tertiary beds were deposited at a great height above them.

The author's third argument (ante) may be divided into three subheads—

(*a*) The author has observed no instance of the intrusion of the granite into the "Tanols."

(*b*) In the author's opinion the "Tanols" are younger than the granite.

(*c*) In all probability the "Tanols" have derived their material from the granite.

The "Tanols" are arenaceous deposits (p. 56); they are sometimes so highly metamorphosed "that there is no longer any direct evidence from individual samples and sections that the rocks are true representatives of what were originally sedimentary deposits" (p. 57). The author considers that they largely represent (pp. 231, 232) metamorphosed sandstones and quartzites of the Infra-Trias; their relative position among the formations in the Hazara district has not been satisfactorily determined (p. 237). The author thinks that possibly the Boileau Gunge quartzites (Krol quartzites) at Simla are of the same age as the Tanols (p. 239), and that the Gondwana formation of Peninsular India is not impossibly represented in part by the Tanols.

The reference to Simla rocks is interesting. In reading Mr. Middlemiss's memoir I frequently came across descriptions of rocks that brought the Blaini, the Krol, and the Infra-Krol series of the Simla area vividly before my eyes. The correlation of the Infra-Triassic conglomerate with the Blaini conglomerate was evidently present to the author's mind, for he says that the supposition that the Infra-Triassic boulder-bed is "homotaxial with the Salt-Range Boulder-bed" is fairly reasonable; and he goes on to state that "there is little doubt that the Panjab conglomerate of Kashmir is nothing but a continuation of the same deposit"; namely, the conglomerate of the Salt Range. The author also speaks with approval of Mr. Lydekker's correlation of the conglomerate of Kashmir with the Blaini conglomerate of the Simla region, and writes (p. 22): "I am disposed to believe in the connection between the Hazara Infra-Trias conglomerate and the Blaini conglomerate."[1]

That being so, a doubt arises whether the "graphitic schists streaking the hillsides black," referred to at p. 250 and elsewhere (pp. 245, 247, and 252), associated with limestones, are not metamorphosed representatives of the "black crush" (Infra-Krol) rock of the Simla area. A further doubt arises whether the "arenaceous beds" referred to at p. 255 and in fig. 52, containing fine interpenetrations of the granite," are not really metamorphosed Tanol (Krol quartzite) arenaceous beds. Also whether the crystalline limestone at Sauvai, associated with the graphitic schists (p. 250), is not really metamorphosed Infra-Trias. If so, the gneissose-granite crops up close to the Sauvai crystalline limestone and is intrusive in the arenaceous beds which I suggest are of Krol quartzite age.

Oldham has shown that Infra-Krol beds are invaded and metamorphosed by granite in the Satlej Valley[2]; and in the Simla area I have identified thick beds of calcareous chloritic schists as highly altered Krol limestone[3]; and I think it highly probable that the arenaceous beds, graphitic schists, and crystalline limestones, described by the author as occurring in his metamorphic zone, are highly metamorphosed equivalents of the Krol and Infra-Krol rocks of the Simla area.

[1] See also author's remarks at p. 247.
[2] Records G.S.I., xxi, p. 149.
[3] Records G.S.I., x, p. 212.

If this surmise should prove correct, the appearance of the granit could not be dated *earlier* than the Carboniferous period, and it migl be much younger.

As regards the subheads (*b*) and (*c*) ante: (*b*) is a mere expressio of opinion and calls for no comment; while I need only say wit reference to (*c*) that the only evidence given in proof of the author contention that the Tanols were derived from the gneissose-granit is that the Tanol beds are composed of coarse-grained quartz felspathic material (p. 239). So also is the Torridonian Sandsto of Scotland! The fact relied on proves no more than that th Tanols were derived from a granite. I and other writers hav heretofore held that an ancient granite, or gneiss, was suffering erosio in, or adjoining, the Himalayan region in Palæozoic times. Th theory is highly probable in itself, and has cogent facts to suppo it. The author's view that this ancient granite was the gneissos granite itself is not proved by the fact that all the granite th author has himself seen is of one kind. My own experience le to a different conclusion—a conclusion adopted by Strachey an other observers. The contention that *all* the granite of the Himalaya is of one age has yet to be proved.

The author's fourth point is the probability that "the volcan rocks of Kashmir (the amygdaloids) of about Silurian age a subærial representatives of the granitic cores" (p. 278).

What this opinion is based on I do not know. At present th only petrographic determination of the Kashmir traps with which am acquainted is the reference to them by Mr. Lydekker,[1] based o a note by myself on specimens collected by him. These sample however, were so altered by aqueous agencies that a determinatio of the rock species, I stated, would, if made, "be to a large exte guesswork." Subsequently I made a rather complete collection the traps on the Chamba border of Bhadarwah, a subdivision of th territory under the Raja of Kashmir, which was published in 1885 These traps consisted of altered basalts, basalt porphyry, andesite felsites, and volcanic ash.

Mr. Lydekker, in his memoir above referred to, tells us that on of his specimens contained 54·1 and another 62·9 per cent. of silic The Kashmir specimens, therefore, would appear to be altered lava belonging to the basic and intermediate classes. So far as th published evidence goes, there seem to be no grounds for considerin the lavas of the Kashmir Valley to be the surface representative of the gneissose-granite of the Himalayas, and the idea of determinin the age of the granite by the age of the Kashmir lavas is, to sa the least, premature.

Lastly, the author (p. 277) relies on the following facts:—

(*a*) The Trias limestone in Hazara is unmetamorphosed.

(*b*) The Infra-Trias of Hazara is metamorphosed in a "mino degree" as compared with the "Slate" series.

(*c*) The metamorphism of the Infra-Trias is attributed to the con tact action of basic dykes.

[1] Memoirs G.S.I., xx (1883), p. 218. [2] Records G.S.I., xviii, p. 93.

These facts are interesting as far as they go; but they fall far short of proving that the intrusion of the granite is Pre-Triassic, or Pre-Infra-Triassic.

As already stated (loc. cit.), Oldham has shown that the gneissose-granite is intrusive in Infra-Krol rocks in the Satlej Valley, which cannot be older than Carboniferous, for the Infra-Krol beds rest on the Blaini group, for which a Carboniferous age has been assigned (compare Mr. Middlemiss's Memoir, pp. 129, 133, 135, and 206).

Mr. Lydekker's description of the rocks in the Shigar and Bráldu regions[1] shows that the Trias and "gneiss" are constantly associated together, and a future detailed examination of that and other regions in the Himalayas, now that we know the igneous character of the gneissose-granite, may show that it is intrusive in rocks of later age than the Carboniferous period. As long as the granite was supposed to be a gneiss—namely, a converted sedimentary rock—no one took notice of contact-metamorphism, for that was supposed to be a part of the general metamorphism of which a gneissic structure was the extreme expression.

Mr. Griesbach has shown that granite traverses and alters rocks of Permo-Carboniferous,[2] Cretaceous,[3] and Eocene[4] ages in Afghanistan. Whether these hornblendic granites (which appear to be either gneissic in part, or to be associated with gneisses) are related to the gneissose-granite of the Himalayas, I do not pretend to say; but, at all events, it is clear that the intrusion of granite took place in Afghanistan, the mountains of which seem genetically related to the Himalayas, down to Eocene times. The evidence at present collected does not, I think, require us to believe that the history of the Himalayas, especially as regards the age of its granite, presents essentially different features from that of the Hindu Kush. If we have Eocene granite in the latter, why not in the Himalayas?

Even if, in the Himalayas, no outcrop of granite should hereafter be found in strata of later age than Infra-Triassic or Triassic, I should not hold that this fact, taken alone, proves that the age of the granitic intrusion is Pre-Triassic. I should not expect to find granite, as granite, in rocks of Miocene or Pliocene age. I should expect to find the representative of the granite in such rocks less holocrystalline in structure than a true granite and more like a porphyrite, or porphyry. In my original description of the Dalhousie rock I mentioned that in places the matrix became so fine-grained that the rock assumed "the outward aspect of a felspar porphyry." This aspect, and the "cryptocrystalline" structure of the mica described in my original papers, and in my address as President of the Geologists Association (Proc. Geol. Assoc., vol. xiv, p. 245), are incompatible with the supposition that the final consolidation of the rock took place under

[1] Records G.S.I., xiv (1881).
[2] Records G.S.I., xix, p. 241.
[3] Memoirs G.S.I., xviii, p. 348. Records G.S.I., xix, pp. 64, 242; xx, pp. 22, 23.
[4] Records, xx, pp. 102, 103.

plutonic conditions, but indicate a more rapid cooling than is consistent with those conditions. These structures, it seems to me, would not now be visible if the rock had taken long ages to cool at a great depth below the surface, with all the rocks later than those of Carboniferous age piled up on the top of it.

I will now pass on to offer a few words of explanation regarding the following observation made by Mr. Middlemiss in the Memoir under consideration. He writes at p. 274 as follows: "Probably the first idea of many people after superficially studying the Himalaya would be to regard the great crystalline axis as having been the cause of the upheaval of the mountain mass, the prime mover, which bursting through the other rocks wedged them apart and folded and contorted them." A footnote to this passage refers to some remarks of mine in my Presidential Address already alluded to.

This reference to my views appears to imply a misunderstanding of their scope. I said that "The contortion, compression, and upheaval which marked the earth movements that set in at the close of the Eocene period, were connected with the intrusion of the gneissose-granite." I said "connected with" advisedly. I did not assert that the granite was the *sole* cause of the contortion, compression, and upheaval, and I did not assert that the "earth movements" were caused by the rise of the granite. I did not for a moment lose sight of the fact that tangential pressure (apart from the rise of the granite) was a potent factor to be taken into consideration; and I spoke (Proc. Geol. Assoc., xiv, p. 289) of the granite being "forced, under conditions of great *lateral* and upward pressure, between the jaws of faults." I remarked that the granite "runs, on the whole, with the strike of the sedimentary rocks, and its outcrop seems to be directly connected with the wrinkling of the strata and the formation of overthrust faults" (loc. cit., p. 93); and again, that the granite was "implicated in the folding in a way to suggest *intrusion* along overthrust faults." These overthrust faults were, I presumed, caused by tangential pressure. I wished to point out that the intrusion of beds of granite—in some cases twelve miles thick, along the whole line of the Himalayas—must have contributed greatly to the compression of the strata. I thought that it would be sufficiently obvious that the compression due to the intrusion of the granite *followed*, and did not precede the formation of the faults, fissures, and planes of weakness, which enabled the granite to penetrate the sedimentary strata. When I spoke of intrusion along overthrust faults I thought the reader would understand that the faults must be formed before the granite was forced into them; and consequently I did not think it necessary to explain that the granite was not the cause of the faulting.

As regards the question of elevation, Mr. Middlemiss remarks at p. 273:—"So far as Hazara and such parts of the higher and lower Himalaya that I have seen are concerned, the rock, if originally a gneiss, must have been so heated as to get at least into a plastic state in which it was capable of considerable movement

under pressure along lines of least resistance. On the other hand, if the rock is really a granite all through, that is to say, the product of a molten magma drawn from some unknown underground reservoir, then its activities as an intrusive rock have been kept well under control."

Whichever of the two views stated by the author be adopted, it is clear that there must have been a reservoir of molten or semi-molten rock at the root of the Himalayas sufficiently capacious to have supplied the enormous masses of gneissose-granite now to be found along the whole length of these mountains, for it is admitted that the granite came into place as an intruder, and it is not suggested that sedimentary rocks were heated up and converted into granite *in sitû*. The author speaks of the "granitic foundations out of which the Himalaya were ultimately to rise" (p. 275)—that, by the way, sounds rather like my own view which the author contests—and he contrasts them with the "gneissic foundations of the peninsula of India" (p. 275); and the author remarks with reference to the theory of those who assert the Archæan age of the gneissose-granite, "even they must admit a pretty thorough mixing of the material by some agency before it quietly found its way in an intrusive capacity among the ancient sedimentary rocks" (p. 276).

The author's views, then, involve the supposition that immediately preceding the intrusion of the granite there was a reservoir of molten or semi-molten rock forming "the granitic foundations out of which the Himalaya were ultimately to rise." That being so, what, I would ask, would be the result of powerful tangential pressure applied to the sides of this reservoir? Would not the granite "rise along the line of least resistance"? This rise of the granite, the author tells us, took place "under such enormous pressure of the superincumbent rocks that an eruptive function was generally denied it" (p. 274), and "it was formed as great laccolites." That being so, would not granite moved upwards with sufficient force to overcome the "enormous pressure" that tried in vain to keep it down, have elevated the rocky cover? I think such elevation would, under the conditions supposed, be inevitable, and that I was therefore fully justified in stating that "the contortion, compression, and upheaval of the Himalayas were connected with the intrusion of the gneissose-granite."

(*To be continued.*)

NOTICES OF MEMOIRS.

I.—A New Fossil Cycad from the Isle of Portland.

(PLATES XIII AND XIV.)

AN example of a Jurassic Cycadean stem of exceptional interest has lately been added to the Fossil Plant Gallery of the British Museum. The specimen is described in detail by Mr. A. C. Seward in the Quarterly Journal of the Geological Society for February of this year.

Geologists have long been familiar with the short and thick Cycadean stems described by Buckland and others from the Purbeck beds of Portland, but the recently acquired fossil differs in many respects from the shorter stems or "crows' nests" hitherto recorded as the common type of Cycads from this locality. The specimen was found in one of Mr. Barnes' quarries, and, as shown in Fig. 1, it was obtained from a bed of shaly clay 17 feet higher in the Purbeck series than the Great Dirt-bed which has yielded most of the Portland plants. Mr. A. M. Wallis, a local guide and quarryman, who at once recognized the value of the specimen, saved it from destruction, and Dr. Woodward was fortunate enough to obtain the magnificent stem for the National Collection.

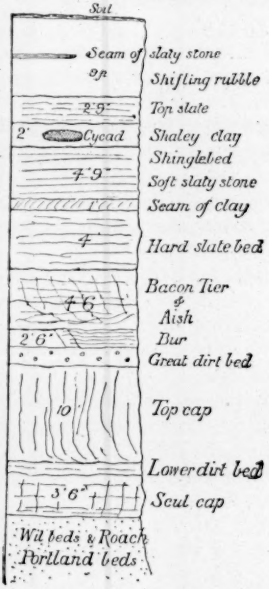
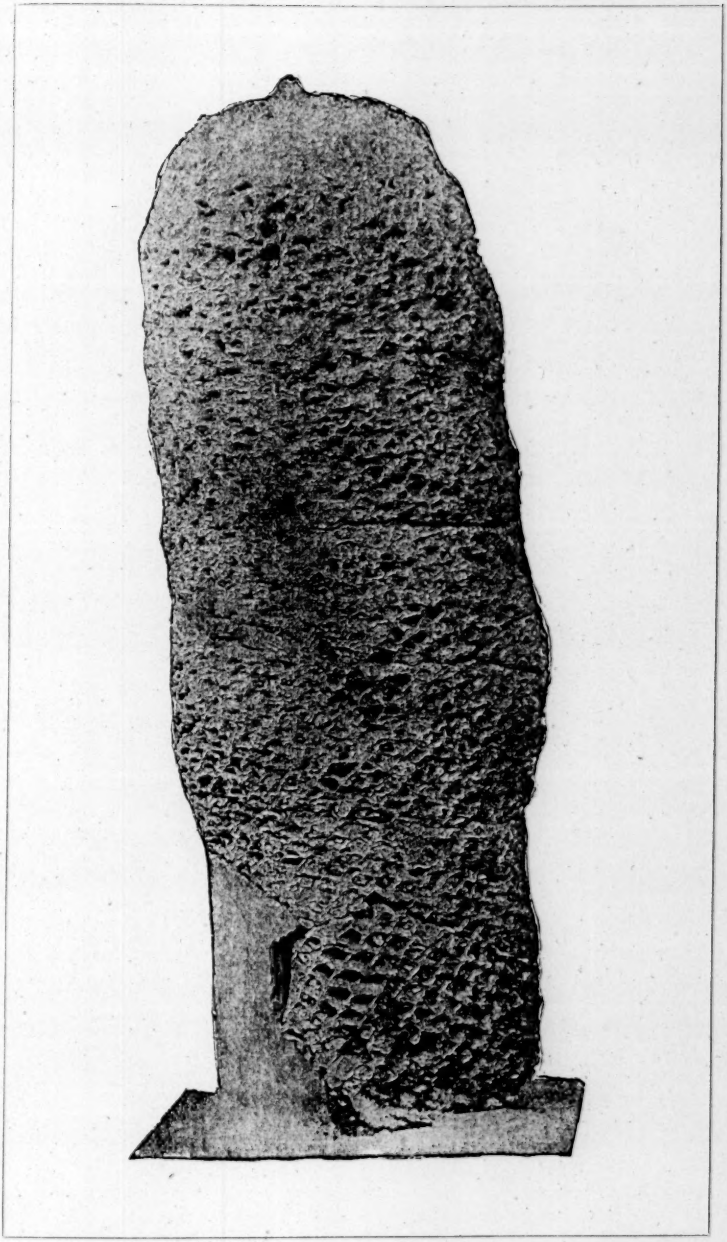


FIG. 1.—Section of the quarry on Portland in which the Cycadean Stem was discovered by Mr. A. M. Wallis.

The trunk is shown in its natural position in Plate XIII, which is reproduced from a photograph taken by Mr. Gepp of the British Museum. The total height is nearly four feet (1 m. 18·5 cm.), and the girth at the broadest part about 1 m. 7 cm. The surface features are best seen close to the base (Plate XIV, Fig. 2); there is a prominent network with meshes arranged in regular rows and passing spirally round the stem. Each mesh marks the position of a leaf-stalk base; the substance of the petiole has disappeared in most cases and left a cavity; the reticulum consists of ridges of silicified tissue, which existed between the individual petioles. In the living plant numerous scaly or laminar appendages were attached to the surface of the petiole base, and these formed a kind of loose packing between the fronds. The chaffy scales or paleæ on the leaf-stalks of many recent ferns are almost identical structures, and among existing Cycads somewhat similar appendages are occasionally met with. The mineralizing solution was apparently absorbed more readily by the interpetiolar tissue than by the less porous petioles; the former was therefore more frequently preserved, and in a better condition than the latter.

At the top of the stem an apical bud has been clearly preserved. It is very unusual to find fossil Cycadean stems in which the apical portion has been left intact. The bud is covered with numerous bud-scales, and at the summit there is a terminal cap, shown in Plate XIV, Fig. 1, as a lighter-coloured patch. In Fig. 2, p. 319, this cap presents the appearance of a mass of numerous fine hairs covering the tips of the linear bud-scales.



Stem of a new Fossil Cycad, *Cycadeoidea gigantea*, Seward.

Purbeck Beds, I. of Portland. $\frac{1}{8}$ nat. size.

FIG. 1.

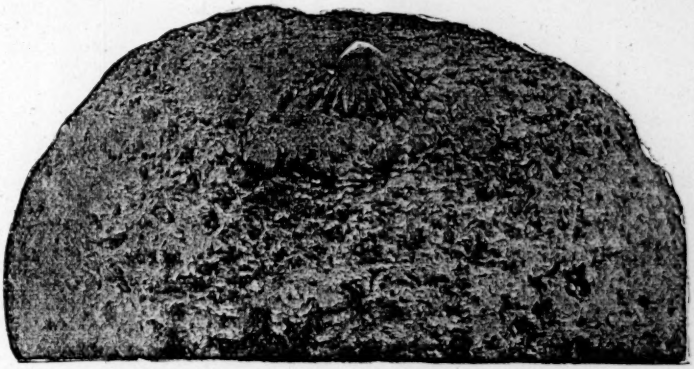
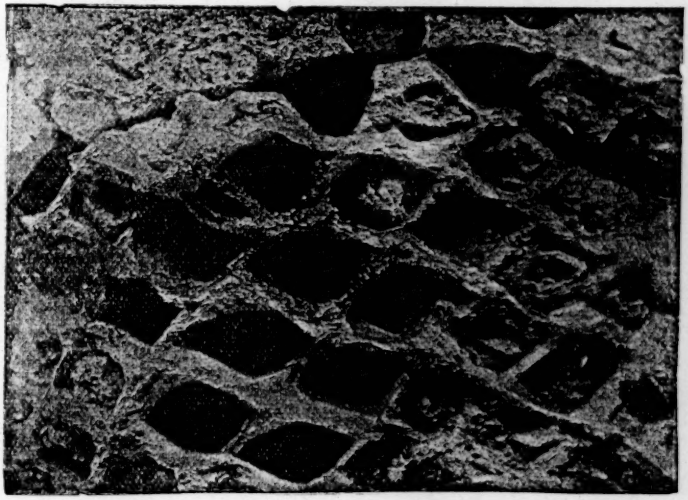


FIG. 2.



FIGS. 1 AND 2.—*Cycadeoidea gigantea*, Seward.

FIG. 1. The apex of the stem shown in Plate XIII ; about $\frac{1}{4}$ nat. size.
FIG. 2. Leaf-bases and ramenta from the lower portion of the stem ; about $\frac{1}{2}$ nat. size.

The apical bud of recent Cycads is occasionally capped by a mass of loose hairs, and there is the closest possible resemblance between the bud of this Portland stem and that of such a recent Cycad as *Encephalartos Altensteinii*, Lehm., a species well represented in the tropical-house at Kew.

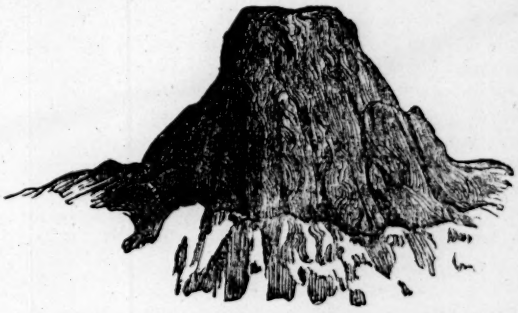


Fig. 2.—Apical bud of *Cycadeoidea gigantea*, Seward.

The material of which the specimen consists is highly siliceous; the central portion exhibits no trace of plant-structure, and is composed of cherty rock, but portions of the more external tissues are in some places exceedingly well preserved. The description of the structure of the petiole bases, and that of the mass of interpetiolar tissue, as given in the more detailed account of the stem, demonstrates a striking similarity between the anatomy of the genus *Bennettites* and that of the new fossil. In the absence of any definite trace of reproductive organs, the Portland stem has been placed in Buckland's genus *Cycadeoidea*, and named *Cycadeoidea gigantea*. As regards the exact affinities of the species, it is impossible, without the evidence of the reproductive organs, to speak with certainty as to its precise position. There is, however, no sufficient reason for regarding the stem as essentially distinct from such a type as is represented by *Bennettites Gibsonianus*, so far as concerns its position in a system of classification.

II.—The Pleistocene Ice-sheet in North America: Englacial Drift. By W. O. Crosby.[1]

Probable Early History of the Pleistocene Ice-sheet.

RECENT researches in North America tend to show that an ice-sheet may over a considerable part of a glaciated area have been formed *in situ* by snow accumulation.

A general refrigeration of the climate in mountainous districts, due chiefly perhaps to a marked elevation of the northern part of the continent, had led to the development of glaciers of the Alpine type in the higher valleys. These glaciers became confluent

[1] Abridged from the *Technology Quarterly*, vol. ix, Nos. 2 and 3. (Boston, 1896.)

as the cold increased, deploying upon the plains and forming sluggish or stagnant Piedmont glaciers. With progressive refrigeration the annual snowfall finally exceeds the annual melting of the ice. This cumulative snowfall, which mantled alike hills and valleys, and changed slowly through *névé* to glacial ice, must have tended in some measure to check or arrest the motion of the ice which had flowed outward from the mountains. Owing, however, to the forward motion of the Piedmont glaciers, as well as to their termination on tracts where a short time before ablation (or melting) had been in excess of snowfall, they must have terminated somewhat abruptly or with high marginal gradients; and the conditions therefore, were extremely favourable for their overriding the new and still stationary ice-fields by which they were invested. The overridden tract of ice must slowly acquire the motion of the overriding sheet, and thus in its turn come to override other tracts. In fact, it seems very probable that this process of overriding and absorption would continue almost indefinitely, extending possibly, over a large part of the glaciated area.

Assuming a uniform annual snowfall over the area of the sedentary ice-sheet, it is obvious that since its area is gradually extended southward by the progressive climatic refrigeration, while the annual ablation as gradually diminishes northward, its thickness must increase backward from the margin. If, however, as Upham holds, and as certainly seems most probable, the precipitation of snow over the growing ice-sheet was not uniform, but greatest from the first one hundred to two hundred miles inward from the margin, the surface-gradient must have culminated on these peripheral tracts, diminishing gradually backward. This condition would, obviously, favour an early beginning of outward movement or flow in the marginal zone, and tend in an equal degree to retard motion in the central area.

We should hardly be justified in supposing that the great crustal movement which gave us the Ice Age, was steadily progressive without interruption or reversal, until its final culmination. No doubt the period of the growth and culmination of the ice-sheet, equally with that of its waning and disappearance, was attended with marked climatic oscillation. During these changes the precipitation and ablation would co-operate in accentuating the frontal slope of the ice-sheet. The chief factors in determining movement of the ice-sheet were its thickness and marginal gradient.

The absence from a large part of the glaciated area of mountains or dominant heights of land, requires us to assume that over considerable tracts the sedentary ice-sheet did eventually begin to flow without having experienced the overriding or shearing thrust of the Piedmont ice-fields. The outward movement thus originating in the peripheral tracts during a period of excessive ablation must have extended backward, perhaps until it met the forward thrust of the Piedmont glaciers.

Assuming therefore that the movement of the ice-sheet was inaugurated during a warm period, and that the southern margin

of the ice has retreated far to the north through ablation, developing a bold and aggressive front, it is obvious that the succeeding cold period must have caused a rapid extension of sedentary ice southward from the front of the moving sheet, and the former would inevitably be progressively overridden and absorbed by the latter.

Basal Relations of a Sedentary Ice-sheet.

During the slow accumulation of the ice-sheet, and before it began to move, the ground beneath it, which must have been saturated with water, was probably frozen solid to a considerable depth, possibly nearly, if not quite, to the bottom of the residuary soil or other surface detritus; that is, down to the firm rocks. There could have been no original plane of separation or movement between this frozen soil and the overlying ice-sheet, for the ice did not merely rest *on the detritus*, but extended down through it to the lower limit of frost.

With increased thickness the ice-sheet became a more and more efficient protection to the ground against the climate of the Ice Age, and the steady efflux of heat from the earth's interior would thus tend to gradually loosen the hold of the frost upon the rocky substratum.

Observations in the Arctic regions and at higher altitudes show that the ground may become frozen to a depth of several hundred feet; but it is well known that glaciated areas are not in general those of most extreme cold. A humid climate is the first essential, whereas extremely frigid areas, such as the interior of Alaska and northern Siberia, are relatively dry and non-glaciated. A mean annual temperature a few degrees only below freezing is all that is required for active glaciation; and as the increasing thickness of a sedentary ice-sheet would tend to neutralize the downward penetration of frost, we need not suppose that the ground beneath the ice would be frozen to any great depth or far below the detrital layer.

In considering the most probable plane of shearing when the ice-sheet begins to move—whether in obedience to its own weight or through the overriding thrust of a thicker northern sheet—we have to consider (1) the ice-sheet proper; (2) the frozen soil beneath it, to which the ice-sheet is still firmly united; (3) the unfrozen soil resting upon or passing downward into the solid rocks. At the inception of movement the most probable plane of slipping or shearing would be in the unfrozen soil, the frozen soil and overlying ice moving *en masse*, and the movement being lubricated by the unfrozen soil, which at most points would be of an argillaceous and plastic character.

Observations heretofore made on modern glaciers and ice-sheets are of little value in this connection, because nowhere in the field of observation are realized the conditions that must obtain at the base of a sedentary or recently sedentary ice-sheet. The true glaciers or ice-rivers of Alpine districts, Greenland, etc., are mere lobes of ice descending under the influence of gravity from the edges of *névé*

fields and ice-caps into a climatic zone where permanent ice cannot form; and hence they are moving over unfrozen soil, and the ice is wasting by melting on its under as well as its upper surfaces. The great desideratum is a shaft or boring in the interior of Greenland extending through the entire thickness of the ice-sheet and a hundred feet into its rocky bed. The Greenland studies of Professor Chamberlin show the facility with which ice shears along innumerable lines of débris; it slides over the débris instead of dragging it along as it would if the débris were firmly frozen into the ice. Granting, however, that the frozen soil would be more rigid and indifferent to gravitative stresses than the clear ice above it, the fact remains that the unfrozen soil at the base is more yielding and plastic than either; and hence, although we may reasonably conceive definite shearing-planes as distributed through a considerable thickness of the ice-sheet, the lowest plane, and the true base of the ice-sheet will still be at the lower limit of frost.

Rectilinear striæ, often scores of feet in length, are an impossibility unless we conceive the entire mass of the ground-moraine as enclosed in the moving ice. These would be produced during the period of active glaciation when the ground-moraine was very scanty or wholly incorporated with the moving ice. A true ground-moraine between bed-rock and ice, and distinct from both, belongs to the waning stage of the ice sheet and to lobes of ice (glaciers) descending from an ice-cap or *névé* field into a climatic zone where permanent ice cannot form.

All this appears to be quite consistent with the local origin of the greater part of the till or ground-moraine of the Pleistocene ice sheet, and the well-established fact that the total movement of the ice amounted to hundreds of miles, if we simply suppose that through the granular plasticity of the ice, or a series of shear-planes, the basal, drift-laden layer moves much more slowly than the overlying clear ice.

Absorption of Drift by the Pleistocene Ice-sheet.

As the initial shearing-plane of the ice-sheet is normally at the lower limit of frost, a considerable amount of detritus is englacial from the beginning of the movement of the ice-sheet. When a sedentary ice-sheet is overridden by a Piedmont glacier, or by the readvance of an earlier ice-sheet, the conditions must be favourable for the transfer of drift from the base of the earlier sheet to a somewhat elevated position in the composite sheet which results from the overriding. The overriding sheet will carry with it not only its own englacial drift, but will drag along a part of its ground-moraine or subglacial drift.

It is altogether probable that each important recession of the ice-sheet, and not only the final recession, was characterized by numerous glacial rivers and lakes, and an extensive development of modified drifts in the well-known forms of kames, eskers, deltas, with abrupt northern margins, etc. Such loose deposits would be taken up by the succeeding ice-sheet.

Relatively slight obstructions to the flow of an ice-sheet, whether of solid rock or uncompacted drift, are sufficient to originate sharp overthrust flexures and oblique shear-planes, marked by bands of débris. Thus drift is transferred from a subglacial to an englacial position. It may be concluded that from the summit or crest of nearly every elevation with an abrupt lee-slope, a stream of detritus flowed onward and upward into the ice-sheet during its progress over the land. On the stoss-slope glacial erosion reaches its maximum intensity, as both vertical and flowage pressure co-operate, and much basal detritus is carried forward and from the summits of elevations into the body of the ice, and not down the lee-slopes.

During the period of maximum glaciation a large proportion of drifts may have been dragged down the lee-slopes in the bottom of the ice, and thus striation and polishing of those slopes were produced. Later, when the vertical pressure was less and the velocity of flow greater, the ice hugged the lee-slopes less closely, and the conditions became favourable for the detachment of blocks of rock. Thus ice penetrated the joint-cracks of the rocks and severed blocks, and these were eventually carried away by the moving mass of ice to which they became attached. Indeed, we often find a surface train of angular blocks leading away from the lee-slopes.

During the later stages of the decline of the ice-sheet, basal melting set free considerable volumes of the hitherto englacial drift to form the ground-moraine; and just as the frontal or terminal moraine, also composed of material set free by the melting of the ice, records the cessation of the forward movement or invasion of the ice-sheet, so the basal or ground-moraine records the gradual cessation of the glacial abrasion of the bed-rocks. Generally the ground-moraine rests upon striated surfaces of the rocks, and as it accumulated it was pressed down by the ice to form the typical "hard pan."

Thus, in the earlier and maximum stages of the ice-sheet the basal temperature was below freezing, and the freezing of subglacial waters made and kept the detritus a part of the ice-sheet; in the later stages of the ice-sheet, the basal temperature rose above freezing, and the ice relaxed its hold on the detritus and flowed over it.

Transportation of drift by simple drag is relatively unimportant, if not impossible; the transportation is almost wholly englacial, as insisted by Upham (Bull. Geol. Soc. Amer., vi, 348), but highly differential, being extremely slow in the basal layers and more and more rapid at higher levels. The detritus reaching the highest levels in the ice is carried farthest, not only because of the higher velocity, but also because it remains for a longer time in the ice.

The efficiency of glacial erosion is clearly proved by the fact that over practically the entire glaciated area north of the terminal moraine *all* the preglacial soil and partially decayed rock have been worn away, and there has been an extensive erosion of the hard

unweathered rocks. The prevailing colour of the ground-morain below the sharply defined limit of postglacial oxidation is that crushed rock, and not of residuary or other preglacial detritus.

Probably no feature of the Greenland glaciers revealed to us b Chamberlin's studies is of greater interest than the beautiful stratif cation and lamination of the ice. This stratification is due chiefly t the mode of distribution of the drift or rock débris, which forn numerous relatively thin and continuous layers approximatel parallel with the bottom of the glacier, and often exhibiting flexure and faults where the ground over which the ice moved was unever This englacial drift is ground-moraine absorbed by the ice throug flexing and shearing movements. The débris is an element of weak ness, and tends to give rise to shearing- and gliding-planes. Whe we consider how intimate this process of lamination-shearing i producing in extreme cases as many as twenty distinct layers in a inch, it can hardly be doubted that the englacial rock-fragments more especially if of small size, must suffer faceting and striatio after the manner of the ground-moraine. Thus one supposed dis tinction between subglacial and englacial drift disappears.

Comparison with Modern Glaciers and Ice-sheets.

That glaciers of the Alpine type are generally free from incor porated drift, other than that derived from lateral and media moraines through the agency of crevasses, is, no doubt, attributabl to the facts that their courses were long since swept relatively bar of detritus, and that in their lower courses they are undergoing basa melting, and hence depositing rather than absorbing drift.

The numerous glaciers descending from the margin of the Green land ice-cap present two types: (1) the drift-laden glaciers whic predominate north of latitude 76°; and (2) the apparently drift-free glaciers to the south. In the former, the drift is strictly a basal feature, rarely rising to greater heights in the ice than 100 to 150 feet, even where the glacier may be a thousand feet or more in thickness. Possibly the northern glaciers are more generally drift laden because the severe climate tends to prevent basal melting, and a considerable part of it may represent the lower, drift-laden portion of the ice-cap itself. The ice-cap virtually spills over the edge of the plateau through deep V-shaped notches; and the conclusion is unavoidable that a much larger proportion of the upper, clear, and relatively mobile ice will flow down, than of the lower, drift-laden, and relatively immobile ice.

It is the general belief of geologists that if Greenland were divested of its ice-cap it would exhibit continental relief—elevated margins and a depressed interior. Probably very little of the englacial drift rises to a greater height than 500 feet, or possibly 1,000 feet, even when the thickness of the ice is one to two miles. None of the suggested processes of absorption seem competent to diffuse the detritus through a more considerable thickness of the ice.

An important exception to this limitation of the range of englacial drift should be made for the case when a later sedentary ice-sheet is

overridden by the readvance of an earlier sheet, the height attained by the englacial drift depending then upon the thickness of the overridden sheet.

Relations of Englacial Drift to Modified Drift.

The modified drift, or washed and stratified gravels, sands, and clays, of glacial origin, forming deltas, terraces, overwash or apron plains, eskers, kames, etc., occur almost wholly in valleys or on lowlands. This drift is due in part (1) to the washing and assorting of the till or ground-moraine by glacial streams during and following the waning and disappearance of the ice-sheet; (2) to the englacial drift through the agency of subglacial streams; and (3) to the melting of the ice and liberation of the englacial drift on its surface where it was washed and assorted by superglacial streams.

The Transportation Argument.

While a small part of the drift of the Pleistocene ice-sheet is far-travelled, the great bulk is of local origin.

Much of the preglacial residuary soil was probably swept away by aqueous erosion during the elevation of the continent and before the formation of the ice-sheet. What was left of it probably became incorporated with the ice-sheet in its earliest stage, and it has ultimately been carried by various agencies, glacial, lacustrine, and fluvial, in large part beyond the limits of the glaciated area. There is little indication of the presence of highly oxidized residuary clay in the till: its matrix is chiefly the finely comminuted and unoxidized detritus.

In its earliest stages the ice-sheet wore away and absorbed a considerable thickness of rotten rock underlying the soil, and during its maximum stage the hard rocks suffered glacial abrasion. On the decline of the ice-sheet, as before mentioned, there was a rending of ledges and detachment of fragments and boulders. These must have been, in general, the last material to be absorbed by the ice-sheet and the first to be deposited by basal melting. Under favourable conditions of flexing and shearing a small part of this material attained a high level in the ice and enjoyed a long glacial transport.

Although the total forward movement of the ice, as indicated by far-travelled erratics, appears to have been as much as five or six hundred miles, and even in some parts of the glaciated area perhaps a thousand miles, a basal slipping of one-twentieth of that distance or less would probably be regarded as sufficient to account for the erosion of the bed-rock surface and the normal distribution of the identifiable fragments. Possibly the total movement of the ice has been overestimated, the more distant erratics having been, perhaps, transported in part by water, and not wholly by the ice-sheet, each marked recession of which provided a series of glacial lakes and rivers along its margin.

It is evident that the entire volume of the drift was englacial during the active erosion of the bed-rock, and that an efficient

protection was afforded to glaciated surfaces by even a thin laye of till. Hence drag as a mode of glacial transportation is not t be maintained—a conclusion at which Mr. Upham had previousl arrived.

REVIEWS.

I.—The Ancient Volcanoes of Great Britain. By Sir Archibal Geikie, F.R.S., D.C.L., D.Sc., etc., Director-General of th Geological Survey. Imperial 8vo. In two volumes. Vol. I pp. xxiv and 477, with seven maps and 175 illustrations. Vol. II pp. xvi and 492, with 382 illustrations. (London: Macmilla and Co., Ltd., 1897. Price 36*s*. nett.) (First notice.)

THE author tells us that the present work is intended to offer summary of what has now been ascertained regarding th former volcanoes of the British Isles. The subject, he says, ha occupied much of his time and thought all through life. Bor among the crags that marked the sites of some of these volcanoes he was led in his boyhood to interest himself in their structure an history. The fascination which they then exercised has lasted til now, impelling him to make himself acquainted with the volcani records all over these islands, and to travel into the volcanic region of Europe and Western America for the purpose of gaining cleare conceptions of the phenomena.

Sir Archibald Geikie has from time to time communicated hi researches, during a period of almost forty years, to the Geologica Society of London and the Royal Society of Edinburgh. The presen work is intended to combine in a general narrative the whole pro gress of volcanic action from the remotest geological periods dow to the time when the latest eruptions ceased.

An opportunity of partially putting this design into executio occurred when, as President of the Geological Society of Londor he delivered the Annual Addresses in 1891 and 1892. Within th limits permissible to such essays, it was not possible to present mor than a full summary of the subject. "Since that time," write Sir A. Geikie, "I have continued my researches in the field, espe cially among the Tertiary volcanic areas, and have now expande the two Addresses by the incorporation of a large amount of nev matter and of portions of my published papers."

The author's labours have culminated in the production of the tw handsome volumes which, if they had been written by any les gifted geologist, would still be of the greatest value to the studen by reason of the wealth of maps and illustrations which they con tain, chiefly from the writer's own notebooks and sketches, an photographs taken by Colonel Evans and Miss Thom, of Canna and by Mr. Robert Lunn for the Geological Survey among th volcanic districts of Central Scotland. When to excellence of illus trations, however, is added the facile pen of Sir A. Geikie, th volumes become as attractive from a literary and scientific poin of view as the pictures are from an artistic one.

In the opening chapter the author traces the influence of volcanoes and volcanic activity upon the mythology of the early Greeks and Romans, and points out the many opportunities which the dwellers along the basin of the Mediterranean must have had of observing these most striking and startling phenomena of nature.

"When in later centuries the scientific spirit began to displace the popular and mythological interpretation of natural phenomena, the existence of volcanoes and their extraordinary phenomena offered a fruitful field for speculation and conjecture. As men journeyed outwards from the Mediterranean cradle of civilization, they met with volcanic manifestations in many other parts of the world. When they eventually penetrated into the Far East, they encountered volcanoes on a colossal scale and in astonishing abundance. When they had discovered the New World, they learnt that in that hemisphere also 'burning mountains' were numerous and of gigantic dimensions. Gradually it was ascertained that vast lines of volcanic activity encircle the globe. By slow degrees the volcano was recognized to be as normal a part of the mechanism of our planet as the rivers that flow on the terrestrial surface. And now at last men devote themselves to the task of critically watching the operations of volcanoes with as much enthusiasm as they display in the investigation of any other department of nature. They feel that their knowledge of the earth extends to little beyond its mere outer skin, and that the mystery which still hangs over the vast interior of the planet can only, if ever, be dispelled by the patient study of those vents of communication between the interior and the surface.

"If, however, we desire to form some adequate idea of the part which volcanic action has played in the past history of the earth, we should be misled were we to confine our attention to the phenomena of the eruptions of the present day. An attentive examination of any modern volcano will convince us that of some of the most startling features of an eruption no enduring memorial remains. The convulsive earthquakes that accompany a great volcanic paroxysm, unless where they actually fissure the ground, leave little or no trace behind them. Lamentably destructive as they are to human life and property, the havoc which they work is mostly superficial. In a year or two the ruins have been cleared away, the earth-falls have been healed over, the prostrated trees have been removed, and, save in the memories and chronicles of the inhabitants, no record of the catastrophe may survive. The clouds of dust and showers of ashes which destroyed the crops and crushed in the roofs of the houses soon disappear from the air, and the covering which they leave over the surface of a district gradually mingles with the soil. Vegetation eventually regains its place, and the landscape becomes again as smiling as before.

"Even where the materials thrown out from the crater accumulate in much greater mass, where thick deposits of ashes or solid sheets of lava bury the old land-surface, the look of barren desolation, though in some cases it may endure for long centuries, may in others vanish in a few years. The surface-features of the district are

altered indeed, but the new topography soon ceases to look new. Another generation of inhabitants loses recollection of the old landmarks, and can hardly realize that what has become so familiar to itself differs so much from what was familiar to its fathers.

"But even when the volcanic covering, thus thrown athwart a wide tract of country, has been concealed under a new growth of soil and vegetation, it still remains a prey to the ceaseless processes of decay and degradation which everywhere affect the surface of the land. No feature of a modern volcano is more impressive than the lesson which it conveys of the reality and potency of this continual waste. The northern slopes of Vesuvius, for example, are trenched with deep ravines, which in the course of centuries have been dug out of the lavas and tuffs of Monte Somma by rain and melted snow. Year by year these chasms are growing deeper and wider, while the ridges between them are becoming narrower. In some cases, indeed, the intervening ridges have been reduced to sharp crests, which are split up and lowered by the unceasing influence of the weather. The slopes of such a volcanic cone have been aptly compared to a half-opened umbrella. It requires little effort of imagination to picture a time, by no means remote in a geological sense, when, unless renovated by the effects of fresh eruptions, the cone will have been so levelled with the surrounding country that the peasants of the future will trail their vines and build their cots over the site of the old volcano, in happy ignorance of what has been the history of the ground beneath their feet.

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"The geologist who undertakes an investigation into the history of volcanic action within the area of the British Isles during past time, with a view to the better comprehension of this department of terrestrial physics, finds himself in a situation of peculiar advantage. Probably no region on the face of the globe is better fitted than these islands to furnish a large and varied body of evidence regarding the progress of volcanic energy in former ages. This special fitness may be traced to four causes: 1st, the remarkable completeness of the geological record in Britain; 2nd, the geographical position of the region on the oceanic border of a continent; 3rd, the singularly ample development to be found there of volcanic rocks belonging to a long succession of geological ages; and 4th, the extent to which this full chronicle of volcanic activity has been laid bare by denudation.

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"There is yet another respect in which the volcanic geology of Britain possesses a special value. Popular imagination has long been prone to see signs of volcanic action in the more prominent rocky features of landscape. A bold crag, a deep and precipitous ravine, a chasm in the side of a mountain, have been unhesitatingly set down as proof of volcanic disturbance. Many a cauldron-shaped recess, like the corries of Scotland or the cwms of Wales, has been cited as an actual crater, with its encircling walls still standing almost complete.

"The relics of former volcanoes in this country furnish ample proofs to dispel these common misconceptions. They show that not a single crater anywhere remains save where it has been buried under lava; that no trace of the original cones has survived, except in a few doubtful cases where they may have been preserved under subsequent accumulations of material; that in the rugged tracts, where volcanic action has been thought to have been most rife, there may be not a vestige of it, while, on the other hand, where the uneducated eye would never suspect the presence of any remnant of volcanic energy, lavas and ashes may abound. We are thus presented with some of the most impressive contrasts in geological history; while, at the same time, this momentous lesson is borne in upon the mind, that the existing inequalities in the configuration of a landscape are generally due far less to the influence of subterranean force than to the action of the superficial agents which are ceaselessly carving the face of the land. Those rocks which from their hardness or structure are best able to withstand that destruction rise into prominence, while the softer material around them is worn away. Volcanic rocks are no exception to this rule, as the geological structure of Britain amply proves."

The first volume treats of the nature and causes of volcanic action, and deals with modern volcanoes. The author next considers ancient volcanoes, and the proofs of their existence to be derived from the nature of the rocks erupted from the interior of the earth. The various types of old volcanoes are described as the Vesuvian type, the plateau or fissure type, the Puy type, and the relative ages to be assigned to these ancient volcanoes. This leads on to the consideration of underground phases of volcanic action, as the intrusive series, vents of eruption, necks, inward dip of rocks towards necks, subterranean movements of the magma, dykes and veins, sills and laccolites, bosses, etc. The influence of volcanic rocks on the scenery of the land. This is followed by chapters on Cambrian and Pre-Cambrian volcanoes, and on the volcanoes of Silurian, Devonian, and Old Red Sandstone time.

We hope next month to take up Volume II, and give a further idea of the nature and extent of this, the latest of Sir A. Geikie's geological and literary ventures; by no means the first, and we trust it may not be the last, which he may contribute to the geology of the Victorian era, a period which covers the best years in the lifetime of our science.

II.—A Textbook of Geology: Intended as an Introduction to the Study of the Rocks and their Contents. By W. Jerome Harrison, F.G.S. 8vo; pp. vii, 343. (London: Blackie & Son, 1897.)

EIGHT years ago Mr. Harrison's "Elementary Textbook of Geology" appeared as one of Blackie's Science Textbooks. It has now developed into the above-mentioned work, which, as the author states, is nominally the fourth edition of his little book. A somewhat larger page and a larger type have now been adopted,

and the work throughout has been revised. A number of new illustrations have been added, and among these are several very effective scenes reproduced from photographs.

As the author has remarked, while it is true that "geology cannot be learnt from books," so it is equally true it "cannot be learnt *without* books." It is difficult to convey any adequate idea of rocks, especially eruptive rocks, from brief descriptions, and the same is the case with minerals. The student should obtain examples of the commoner rocks and minerals, and personally examine as many as he can of the common and characteristic fossils. He or she will then be able to make good progress with the help given by Mr. Harrison, and it is noteworthy that his book has rendered much service to those who have attended classes connected with the Science and Art Department. Concise and systematic as this text-book is, we can confidently recommend it as an excellent introduction to geology.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—May 26, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "On Augite-Diorites with Micropegmatite in Southern India." By Thomas H. Holland, Esq., A.R.C.S., F.G.S., Officiating Superintendent, Geological Survey of India.

This paper deals with a series of basic dykes intersecting the pyroxene-granulites and gneisses of the Madras Presidency, and believed to be of the same age as the lava-flows of the Cuddipah system. These dykes consist essentially of augite (near hedenbergite) and a plagioclase-felspar (near labradorite), between which we find masses of micropegmatitic intergrowths of felspar and quartz, with a micro-miarolitic structure. Around the patches of micropegmatite, chemical changes have frequently taken place in the minerals of the rock. Similar occurrences of micropegmatite in basic rocks have been described by J. A. Phillips and Waller at Penmaenmawr, by Hill and Bonney in Charnwood Forest, by Teall in the Whin Sill and in the Cheviot district, by the last-named author and Harker at Carrock Fell, by Sollas at Carlingford, and by Harker in Skye.

After discussing the chemical constitution of the rock and of its various constituents, and the relation between the micropegmatite and the surrounding minerals, the author points out that three methods for the formation of the micropegmatite may be conceived of:—

(α) During the primary consolidation of the magma.

(β) By secondary changes induced in the rock.

(γ) By subsequent intrusion of granophyric material into the augite-plagioclase rock.

In opposition to (γ), the author points out the entire absence of granitic intrusions in the neighbourhood. He regards the absence

of all proofs of subaerial hydration and the remarkable freshness of the rocks as precluding the possibility of the micropegmatite having been formed by secondary change. The primary origin of the micropegmatite he believes to be proved by—(1) the crystallographic continuity of its felspar with that of the normal plagioclase of the rock; (2) the mode of occurrence of the micropegmatite, filling in the angles and spaces between the augite and the plagioclase; and (3) its variation in coarseness of grain agreeing with that of the remaining two constituents of the rock.

These augite-diorites with micropegmatite are then compared with the granophyric gabbros of Barnavave, Carlingford, described by Professor Sollas, to which the author maintains that his explanation equally applies. He insists that the separation of the acid and basic materials of a magma, which takes place so frequently on a large scale, equally occurs in the midst of a consolidating mass, and combinations such as that described in the paper will be formed. He insists also on the proofs of close genetic relations between the gabbros and "granophyres," and of their practical contemporaneity in the various districts in which these phenomena have been noticed.

2. "The Laccolites of Cutch and their Relations to the other Igneous Masses of the District." By the Rev. J. F. Blake, M.A., F.G.S.

The author has observed thirty-two domes of various kinds in Cutch, distributed as follows: (i) those connected with the northern islands; (ii) those of Wagir; and (iii) those along the northern edge of the mainland. They are divisible into four classes: (*a*) those which are so elongated on the line joining adjacent ones that they seem to be mere modifications of anticlinals, though the supposed anticline is not really continuous; (*b*) those which lie in a line, but are not elongated in that direction, and often in no other; (*c*) those which are related to a fault, which cuts them in half; and (*d*) those which are not in any particular relation to each other, or to any other stratigraphical feature.

The domes vary in degree of perfection: some are irregular, while some have the strata running in concentric circles, the outer and newer strata dipping away from the inner and older. In no less than ten of the thirty-two domes igneous bosses are found occupying the centre, and these are distributed amongst all of the above classes. The author gives reasons for maintaining that the domes are the results of intrusion of igneous rocks in the form of laccolites, and are not anticlinal folds which have afterwards been affected by cross-folds. The domes are contrasted with igneous peaks which occur in abundance in a different part of the area, usually at a higher horizon of the strata and at a higher level above sea. These are probably volcanic pipes through which the lava was forced and extruded at the surface.

The author compares the rocks of the bosses with those of the dykes and flows. Both are principally perfectly fresh dolerites, but the former are distinguished by the presence of intergrowths of micropegmatite as the last stage of consolidation, as in the "Konga

diabases." There is also among them a felsite-breccia with micropegmatite developed in the cracks.

He considers that nearly all the igneous rocks of Cutch have been derived from a single magma, which in a solid condition must have contained large crystals of augite, olivine, and ilmenite in a groundmass of lime-felspars, and have been throughout of a basic character. Such a magma originated in more than one centre. One was possibly not far from the Sindree basin, whence lines of weakness diverged. Along these, owing to the thickness of the strata, there was no extrusion at the surface, and laccolite-domes were formed. Where the rock reached higher levels, it spread out into sheets between the domes and aided in the production of synclinals. Another centre was west of Bhuj, where the rock reached the surface without materially disturbing the sedimentary rocks, and formed the so-called "stratified traps." There were also areas here, especially to the south, where escape was impossible and domes were formed.

The author observes that his conclusions, if correct, may be applied to explain the source of the Deccan trap without eruptive centres. It may have been forced out from innumerable orifices as from a sieve, none of these being so much larger than others as to make a definite centre.

II.—June 9, 1897.—Dr. Henry Hicks, F.R.S., President, in the Chair. The following communications were read:—

1. "The Cretaceous Strata of County Antrim." By W. Fraser Hume, D.Sc., F.G.S.

The paper, which deals with the Irish Cretaceous strata, is divided into four parts.

(1) This contains a detailed account of the principal subdivisions, their local distribution and characteristic fossils. The area occupied by these rocks is separated into five divisions, each marked by special lithological and palæontological features. These are—(*a*) The Southern Division, extending from Moira to Lisburn. Here the highest zone of the Chalk, that of *Belemnitella mucronata*, rests directly on the Triassic strata, the junction-bed containing large pebbles, associated with the above-mentioned species. (*b*) The Central Division, mainly including the sections between Lisburn and Belfast. All the main lithological features are here displayed, namely: (i) Glauconitic Sands (a blue-green rock rich in glauconite); (ii) Glauconitic Marls; (iii) Yellow Sandstones (a light calcareous sandstone); (iv) Chloritic Sands and Sandstones of the *Exogyra columba* zone (yellow-green sands and sandstones); and (v) White Limestone. Under No. iii Tate and Barrois both included the zone rich in *Inoceramus*-fragments occurring in the next division, but this zone is different in colour and chemical composition, and is practically absent in the Central area, the White Limestone with conglomeratic or nodular chalk at the base resting unconformably on the lower beds. Palæontologically, all these lower beds are rich in large dimyarian bivalves, especially *Trigoniæ*, *Arca*, *Cucullæa*, etc.

(*c*) The Eastern Division, extending along the Eastern coast from the neighbourhood of Carrickfergus to north of Carnlough, including Island Magee. The Glauconitic Sands and Yellow Sandstones with chert are present, but generally thinner than the same beds in the Central area. In them dimyarian bivalves are very rare, Brachiopods of stunted forms, corals, and sea-urchins having been, on the contrary, only found in them in this eastern region. The *Exogyra columba* zone is barely represented, but the *Inoceramus Crispi*? zone (which Tate thought to be below that of *Exogyra columba*) attains a thickness of over 20 feet, and evidence is brought forward to show that it overlies the *Ex. columba* zone. There is a palæontological unconformity between the two zones, the *Inoceramus*-beds passing insensibly into the White Limestone without the intervention of a conglomeratic bed. (*d*) The Peninsular Division. In the northern portion of county Antrim, the highest zones of the White Chalk rest on Archæan, Carboniferous, and Triassic rocks (which must have formed a peninsula or insular area in the Cretaceous sea), the basal conglomeratic bed being well marked, and old Cretaceous beaches preserved. Finally (*e*) The Northern Division. This occupies a strip on the northern and north-eastern shores, and includes Rathlin Island. The lower beds are only feebly developed, while the three highest zones of the White Limestone (*Belemnitella vera* to *B. mucronata*) attain a great thickness, and are very pure chalk-beds. Taking the various divisions together, it is concluded that Divisions *b*, *c*, and *e* first underwent depression, area *b*, being nearest to the shoreline, Divisions *a* and *d*, being higher ground, and only becoming submerged at a late period in Upper Chalk times.

(2) Chemical and Micromineralogical examination of the lithological types.—The Glauconitic Sands are characterized by the abundance of glauconite (23 per cent. $CaCO_3$), showing evidence of having been formed in the interior of foraminiferal shells; the Glauconitic Marls by an abundance of spheres and rods of pyrites; the Yellow Sandstones by a series of heavy minerals, notably rutile, zircon, tourmaline, kyanite, and perfectly-formed crystals of garnet; the *Inoceramus*-zone contains delicate glauconitic meshworks of hexactinellid sponges and silicified portions of *Inoceramus* and Brachiopods, besides an abundant series of heavy minerals. In the Chloritic Chalk above the Glauconitic sponge-casts become very abundant, associated with delicate casts of Foraminifera; the White Limestone itself has scarcely any residue. The analyses show that the percentage of carbonate of lime increases steadily from base to summit, the Glauconitic Marls alone being an exception.

(3) This section deals with the stratigraphical conclusions. The Glauconitic Sands, regarded by Tate as equivalent to the lower portion of the Upper Greensand, and by Barrois as synchronous with the upper beds (*Pecten asper* zone) of the same formation, are regarded as having commenced to be deposited in the earlier portion of that period, and to have been still forming during the *Pecten asper* times in England. The Yellow Sandstones with chert are mainly equivalent to the Warminster Sandstones with chert in the south-west

of England. The above two beds therefore constitute the Upper Greensand in Ireland. The *Exogyra columba* and *Inoceramus Crispi*? zones were both considered by Tate as Cenomanian, and by Barrois as Turonian. In the present paper they are considered as absolutely distinct, the *Exogyra columba* zone being truly Cenomanian (as limited by Jukes-Browne and Hill); the *Inoceramus Crispi*? zone, on the contrary, being similar in its fauna to the Chalk Rock and lowest Senonian beds in England, and on theoretical and faunal grounds being in preference assigned to the latter.

The *Micraster*-zones of the Senonian have been directly recognized, but the higher ones of *Belemnitella vera* (*Marsupites*) and *B. quadrata* are well represented. The nodular beds at the base of the White Chalk are of varying age, but generally referable to the above two zones. The conclusion arrived at is that there was a gradual depression followed by a partial elevation, and subsequent depression of a far more pronounced character. The Central Division being nearer the shore, the deposits of detrital material here formed were thicker, but at the same time during the period of elevation the denudation was more considerable, so that the unconformity is very marked; in the Eastern Division, where the sea is considered to have been deeper, the detrital deposits were not so thick and denudation less pronounced; on depression commencing at the beginning of the Senonian period, limestones containing a Chalk Rock fauna were being laid down here, while denuding influences were still active in the Central area. Speaking generally, there was a deepening northward of the Cretaceous sea, but the high ground in the north of county Antrim and south of Lisburn was the cause of the very marked beach and conglomeratic features observed in the Peninsular and Southern districts.

(4) *General Questions.*—The author here touches on and discusses (i) the occurrence of certain organic remains in the glauconitic sands and yellow sandstones of the Eastern division, which suggest higher zonal conditions than those indicated by the species with which they are associated; (ii) the great development of the *Exogyra columba* beds south of Belfast and their feebleness north of that town, while the opposite holds in the case of the strata with *Inoceramus*-fragments and *Spondylus speciosus*; (iii) cases of unconformity and overlap in the series; (iv) the existence of definite beaches of Upper Chalk age; (v) evidence in favour of the influence of currents; (vi) the relation of the Spongiarian bands to the strata above and below; (vii) faunal repetitions; and (viii) the general distribution of the *Rhynchonellæ* and *Terebratulæ*.

2. "An account of the Portraine Inlier." By C. I. Gardiner, Esq., M.A., F.G.S., and S. H. Reynolds, Esq., M.A., F.G.S.

At the north-western corner of the inlier a coarse conglomerate, referred to the Old Red Sandstone, dips in a north-westerly direction, and from beneath it a series of green and purple andesites having a south-easterly dip appear. These andesites have undergone considerable change since their extrusion. They are succeeded by a conglomerate of varied character, of which the matrix is at first

an ashy shale, including fragments of ash, andesite, shale, and limestone. Interbedded with the conglomerate are bands of limestone and shale, which have yielded fossils of Middle Bala facies. The authors give reasons for maintaining that this conglomeratic series is not due to earth-movement, but is a sedimentary accumulation, though the case is otherwise with a conglomerate developed along a thrust-plane which separates the volcanic series from an overlying limestone. This conglomerate is compared with one recently described in the Isle of Man, though the alteration which marks the latter is practically absent from the former.

Igneous rocks like those found to the north-west of the outlier are also seen at the southern end.

The general succession of the greatly disturbed Portraine Limestone Series from above downwards is: (3) thin-bedded limestone, with shaly partings; (2) beds of compact crystalline limestone, with many fossils; (1) thin-bedded limestones, with shaly partings: the upper beds being in places crowded with corals. This limestone is comparable with the Chair of Kildare Limestone, and also with the *Staurocephalus*, Keisley, and Sholesbrook Limestones of Great Britain. Succeeding the Limestone Series, and separated from it by a thrust-conglomerate, is a Grit Series, which has yielded no fossils, but which resembles the Balbriggan Grits containing black shales with Birkhill graptolites.

Mr. F. R. C. Reed, M.A., F.G.S., in an Appendix, gives a list of the fossils found by the authors, and offers some remarks upon the age of the deposits.

3. "Some Igneous Rocks in North Pembrokeshire." By J. Parkinson, Esq., F.G.S.

The acid rocks described in this communication are situated at the east end of the Prescelly Hills. Organisms have occasionally been found; and some discovered half a mile west of Crymmych, at the west end of the area, point to an Upper Arenig or Lower Llandeilo age for the deposits.

The masses of acid rock which occur at Foel Trigarn and Carn Alw show all the characteristics of a true lava-flow. The rock often shows beautifully developed flow-structure. Some of the rocks are very markedly spherulitic and axiolitic. The axiolitic rocks display an interesting structure which the author believes to be best explained by concluding that during the formation of the axiolitic growths a slight movement occurred in the unconsolidated magma. He gives a full account of the variations which mark the spherulitic and axiolitic structures, and also describes nodular bodies produced by flow-brecciation accompanied by very feeble radial growth, and showing irregular but more or less central quartzose areas.

After describing a brecciated rock, which on the whole is best accounted for by a process of flow-brecciation, due to a second lava breaking up the first while it was still in a plastic condition, the author describes true pyroclastic rocks, and concludes with a description of the conspicuous intrusive diabases, which, in part at all events, seem to be of the nature of a laccolitic intrusion.